A Natural Resource Inventory for the Sourland Mountain Region

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Table of Contents

List of Figures

"We cannot solve problems by using the same kind of thinking we used when we created them."

Albert Einstein

Executive Summary

This Natural Resource Inventory has been prepared as part of an overall study funded by the New Jersey Department of Community Affairs and the New Jersey Office of Smart Growth. With the Sourland Planning Council as a sponsor and project partner, the five municipalities that share the core of the Sourland region (East and West Amwell Townships, Hopewell Township, Montgomery Township and Hillsborough Township) applied for grant funding to prepare a variety of studies to better understand the region. The first phase of the project is to provide a characterization of the natural resources of the region and assess groundwater resources; phases that will follow will summarize and compare municipal regulations as they relate to the region, assess development potential through build-out analysis and provide a Conservation and Open Space Plan that will identify policies and actions that promote sustainability for the region.

The Sourland Mountain region possesses a number of unique natural features and resources that combine to form what can only be characterized as a fragile ecosystem. While situated between New York and Philadelphia in a corridor that has experienced tremendous population growth in the last 30 years, the core of its fragile resources has remained relatively intact and continues to thrive. But careful management of development and protection of habitat are the only measures that will ensure the long-term survival of the region.

Most development that occurred in the region between 1972 and 1995 came at the expense of agricultural land, as evidenced in land use/land cover information provided by Rutgers University (Grant F. Walton Center for Remote Sensing and Spatial Analysis) and the New Jersey Department of Environmental Protection (NJDEP). More than 4,200 of the 20,000 acres (21%) of agricultural land present in 1972 were converted to developed land uses by 1995. Additionally, the region experienced a loss of 7% of forest present in 1972, roughly 1,800 acres. Given the inter-relationship of these land cover types in providing habitat for both resident and migrating birds, these losses are deemed significant.

The geology that created the unique topographic features known as the Sourlands also brings about limitations for the installation of septic systems and the withdrawal of groundwater through domestic wells. The hard bedrock present at shallow depths creates limited opportunity to install septic systems that will properly treat effluent. Most of the groundwater that reaches bedrock aquifers does so through cracks and fissures; with limited cracks and fissures present in the hard bedrock types of the region, infiltration is also limited. There are also concerns that improperly treated septic effluent could flow along the boundary between soil and bedrock and enter fissures, mixing with groundwater and creating health hazards.

The soils of the study area are varied in composition. The majority are favorable for agriculture, with over 58% of the soils classified as prime or of statewide importance. Most of the agriculture present in the region is on the fringe of the study area, however. In terms of suitability for septic systems, more than 46% of soils are considered unsuitable for the installation of septic systems, according to regulations adopted by the NJDEP in 1999. This is largely due to the shallow depth to bedrock and seasonal high water that a number of soils in the region exhibit.

The Sourland Mountain region acts as headwaters to a number of streams which flow into other areas of Central New Jersey. While only the Alexauken Creek is currently designated a Category One (C-1) water by the NJDEP, there are a number of other streams that could potentially qualify for C-1 designation based on the limited impervious cover in their drainage areas and the nature of their fragile surroundings. A number of streams have been proposed for designation through both the NJDEP and the public and will be considered over the next few months. In terms of existing water quality, a number of the streams within the study area exhibit moderate impairment in their ability to support macro organisms. Through analysis of NJDEP water quality monitoring data, it appears that some streams are tending towards improving quality.

The wetlands present in the study area play an important role in providing habitat for wildlife. Many of the wetland areas are also forested and combine with uplands areas to form the largest contiguous forest remaining in Central New Jersey. These wooded wetlands also store and transmit water to streams which flow into other areas of Central New Jersey.

Riparian areas, or the areas immediately surrounding surface waters, are an important part of the ecosystem that serves a multitude of functions. In addition to controlling water temperature, stabilizing the stream bank, filtering pollutants from runoff, controlling sedimentation and contributing organic matter to the stream ecosystem, they are uniquely suited to passive recreation activities and can serve as corridors for wildlife migration.

The Sourland Mountain region is an ecological island in Central New Jersey, essential to the survival of populations of breeding and migrating birds. The geology, soils, wetlands, forest and grasslands combine to create an environment uniquely suited to sustain an incredibly diverse array of plants and animals that call the region home. Loss of or impact to any of these resources, particularly the understory of the contiguous forest canopy, will have a direct effect on these species and the biodiversity of the area. Although anthropogenic or manmade activities have the most impact, natural forces can prolong and often enhance the effect that humans initiate through development.

Data on the importance of the Sourland region continues to become available, as more scientists and organizations focus their attention on identifying the resource factors that make the area unique. Of particular interest is the richness of bird species, both resident and migrant. Composition of the old-growth forest, including the understory habitat critical to migrating species is unique, making the Sourland forest an important stopover along migratory routes. Also important are successional shrubland and grassland habitats that are present on the Mountain proper and its flanks, which lead to the Amwell and Hopewell valleys. The vernal pools and emergent wetlands of the region also serve as habitat to a number of threatened or endangered herpetile species.

Introduction

The Sourland Mountain is a region at the crossroads. As a crossroads of the American Revolution, it holds secrets and can tell tales from our early life as one of the original Colonies. As an essential stopover for Neotropical migrants in the flyway between Central America and Canada, it is an avian crossroads. The Sourlands are also a crossroads for commutation between homes and places of employment, which are increasingly widely spaced and disconnected from historic centers. And as the Sourlands region enters the 21st century, valuable natural resources, including the limited water supply, are threatened by random and piecemeal development.

Set amid productive agricultural valleys to the north and south, the Sourlands are situated midway between New York and Philadelphia, in a region which has been dramatically altered by development. A place rich in history that extends far beyond the Lindbergh kidnapping, the lower elevations of the mountains were first settled by the Lenape Indians, whose Unami tribes farmed the agricultural valleys that flank the mountain. However, the hostile environment of hard rock and scarce water limited their exploitation of the mountaintop.

The Sourland Mountain formed over 150,000,000 years ago, during the Triassic and Jurassic Periods, the result of continental separation or rift. This inhospitable environment discouraged significant settlement by the Europeans who migrated to the area in the 18th century, and had a similar effect during the 19th century. The latter part of the 20th century, however, brought technological advances that aided human settlement of areas previously deemed too harsh. These new or improved technologies, which provided techniques for disposal of human waste and devices to extract the limited available water, now pose a significant threat to the overall ecological health of the mountain.

As we deal with these issues in the 21st century, it is important to recognize that unbridled human activity will provoke exploitation of sensitive and limited resources beyond their limits. A sustainable future for the Sourland Mountain and the fragile ecosystem that it encompasses will depend on limiting residential and commercial expansion and shaping new development to maintain and reinforce the ecological balance and prevent forest fragmentation and competition for limited water supplies.

Sensitive environmental features, like the vernal pools that support rare species, are highly susceptible to being lost or compromised. Increasing consumer demands for potable water can also have the effect of robbing the base flow from streams whose biota are indicative of high environmental quality. Limiting the demands we place on these resources will be essential to the long term health of the region.

This Natural Resource Inventory provides data that will help to coordinate the resource protection efforts and concerns of the municipalities and three counties that together will shape the fate of this fragile landscape. It recognizes that geography, not political boundaries, defines the Sourlands.

The Study Area

The study area for this Natural Resource Inventory expands on a 64 square mile (40,886 acre) boundary previously defined by Joel Coyne and Jerry Haimowitz for study undertaken by the Sourland Planning Council. This boundary was based largely on the extent of the forest canopy and was meant to incorporate the majority of the Jurassic Diabase formation that comprises the Sourland ridge and other topographic highs of the region. More recent study of the Sourland region has focused primarily on the issue of water supply, vis-à-vis groundwater resource studies prepared for East Amwell, West Amwell and Hopewell Townships. As such, for this more detailed analysis of natural resource factors affecting the region, the study area was expanded to 87 square miles (55,731 acres) to encompass recharge areas and other important habitat types on the flanks of the Sourland ridge. For the most part, the study area boundary represents the limit water flowing out of the Sourland region would reach.

While the expanded boundary may not represent what many feel is the essence of the Sourland region, it will aid in further identifying the extent of impact that land uses in these areas have on the resources of the Sourland Mountain. Analysis of a larger study area will also permit determination of the true core of the region, allowing for prioritization and protection of critical resource factors to aid future planning efforts.

Throughout this Natural Resource Inventory, a number of terms are used to describe a variety of geographic areas. "The Sourlands" refers to all of the topographic formations within the study area, including the Sourland Mountain, Baldpate Mountain, Pheasant Hill and Pennington Mountain (see Figure 22). "The Sourland Region" refers to the entire 87 square mile study area. "The Sourland Ridge" refers to the Diabase formation that forms the Sourland Mountain itself. These terms are interchanged throughout this document and are important to defining the context of the discussion presented.

Purpose and Objectives

A Natural Resource Inventory (NRI) identifies, quantifies and describes the environmental resources present in the community. Through mapping and description, critical factors can be identified and highlighted; this process forms the basis for determining relative importance for future planning efforts.

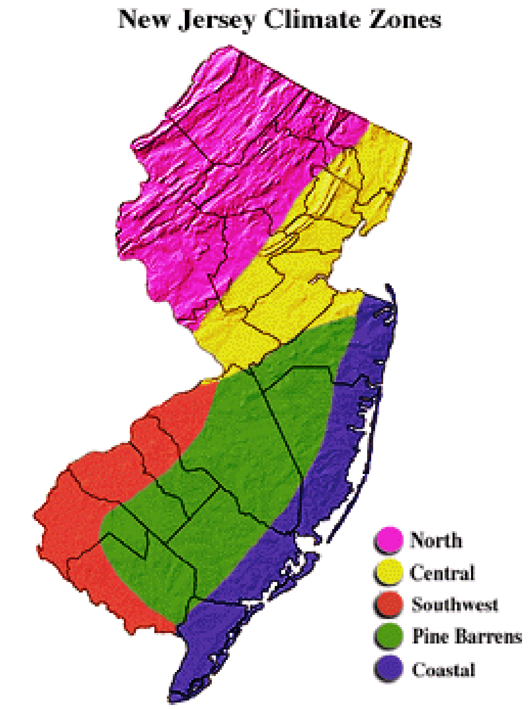
GIS digital data has simplified the quantification and description of resource factors. The ease with which data can be analyzed and displayed allows detailed study to be undertaken for a large area. The inter-relationship of physical features and their relative importance can be identified. In this fashion, both competing and synergistic relationships among natural resources can be defined and explored.

An NRI is particularly useful in identifying and describing many of the natural resources and factors that play a unique role in planning and community development. It is often the basis for future efforts to establish land use and preservation policies in community planning documents; these documents will shape the future of the region.

The purpose of this Natural Resource Inventory is to document in detail the resources and importance of what most intuitively view as an extremely fragile ecosystem. The objective is to provide a firm basis for the establishment of sustainable policy and land use regulation by the communities that share the Sourland Region. This study will likely point to larger issues that require action at higher levels. The objective is to provide enough information to initiate more in depth study where required.

Climate[i]

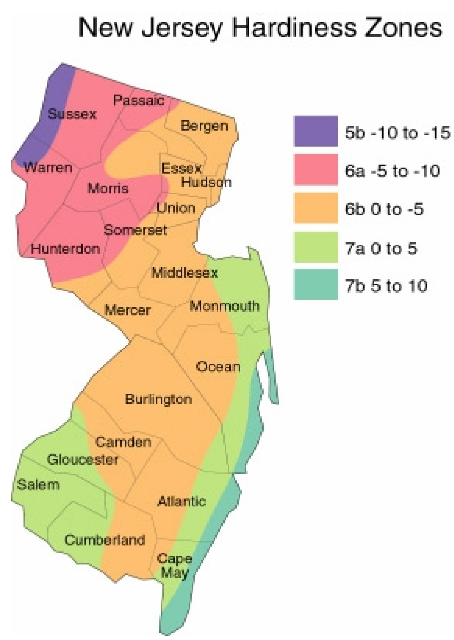
While the study area for the Sourland Mountain region is in both the central and north climate zones of New Jersey, the majority and core of the mountain is in the north climate zone, as depicted at right. Neither climate zone is generally influenced by the Atlantic Ocean and thus have a continental type of climate. Prevailing winds are from the southwest in summer and from the northwest in winter. The continental type of climate means the Sourland Mountain region generally has colder temperatures and greater snowfall in winter, with a greater average annual precipitation overall as compared to areas in southern New Jersey.



Source: *Office of the New Jersey State Climatologist, Rutgers University.*

Based on 30 years of data from weather stations in Flemington and Lambertville, snowfall amounts average 20.9 to 29.1 inches annually, with 48.77 to 49.79 inches of precipitation throughout the year. Generally, January is the month with the most snowfall, averaging 7.5 to 9.5 inches, while May averaged the most precipitation (4.86 inches) over 30 years in Flemington and July averaged the most precipitation in Lambertville (5.06 inches). Spring and summer months tend to experience temperatures consistent with those found in the rest of the state, averaging between 49 and 73 degrees Fahrenheit.

The difference between the continental and coastal climate types has a profound effect on length of growing season, characterized by the dates of first and last killing frost. Varying within the region as well as from year to year, the growing season can be as short as 136 days to as long as 235 days with an average length between 158 and 191 days 9 years in 10 (based on data from Flemington weather station). The average date of the last killing frost is April 27 and the average date of the first killing frost is October 13. Areas within the north climate zone have, however, experienced killing frosts as early as September and as late as June.



Source: *Purdue University Center for New Crops and Plant Products*

Another climate indicator is the hardiness zone established by the United States Department of Agriculture. As depicted on the map to the right, the study area falls within Zone 6b, with an average annual minimum temperature range of 0 to -5 degrees

Fahrenheit.

Hardiness zones are critical for successful cultivation and maintenance of plant material. Plants are rated by the minimum zone that can be tolerated. As an example, if a shrub is rated as hardy in Zone 7a, it will tolerate an average annual minimum temperature of 0 to 5 degrees Fahrenheit, and can survive in any Zone above 7a. It would likely not survive winters in the Sourland region, however, as it is rated within Zone 6b. Aside from cold hardiness, a number of other factors affect plant growth. These include soil pH, sun exposure, rainfall and artificial micro-climate factors. Artificial micro-climate factors are those which can be altered by the nature of the built environment; proximity of buildings, artificial landform (severe grading), adjacency to a highway or parking lot and planting of material in planters or other elevated structures can all affect plant growth.

Land Use/Land Cover

According to 1995 data on land use/land cover published by the New Jersey Department of Environmental Protection (NJDEP), the Sourland Mountain region is primarily characterized by forest (43.3%) and agriculture (28.9%) land cover types. Urban land cover accounts for 13.9% of the region while wetlands (12.8%), barren land (0.7%) and water (0.3%) account for the remainder. Figure 1 depicts a Level I (generalized) Land Use/Land Cover classification for the region based on the Anderson classification scheme, which was developed in the late 1970's as a standard for land use/land cover interpretation. The Anderson scheme classifies all land uses first on a general level (urban, agriculture, forest, wetland, barren and water), then provides further general distinction along with detailed distinction There are three levels of classification possible, Level III being the most detailed.

Urban land uses are generally scattered throughout the Sourland Mountain region, with concentrated nodes found on the flanks of the ridge itself (see Figure 1). The majority of land classified as urban is found in Hopewell Borough, at the base of the Mountain in Montgomery, Hopewell, Hillsborough and West Amwell townships and concentrated along the Route 31 corridor in the central part of the study area. The pattern of development has, for the most part, left many of the forested areas which comprise much of the region intact. The Sourland ridge itself, comprised of the Diabase is dotted with limited development.

The Sourland Mountain's forested acreage is concentrated in three distinct areas; two of these areas are separated by the Route 31 corridor, which divides the region roughly in half. The third area is Baldpate Mountain, in the southwest portion of the study area in the northwest corner of Hopewell Township. And while wetlands comprise only 12.8% of the land cover types found in the region, in relative terms this is a fairly large part. A majority of the wetlands on the Sourland Mountain itself are deciduous wooded wetlands, which could be duly classified as forest as well.

But what general figures illustrating land cover characteristics for the region do not express is its essence; deep forest, grassland and forested wetlands. These factors lend to the feeling that people get from this place, both those who live here and those who visit. They are the critical elements that together define what is important about the Sourland region. The interrelationship of these macro-level features provide continuity that promotes incredible diversity.

Figure 2 depicts the 1995 land use/land cover of the region in a more detailed fashion, expanding on the 6 general categories contained in the Level I Anderson classification. This breakdown, generally representative of a Level III classification scheme (although terms are slightly modified) details the types of forest, wetland, urban and agricultural land detailed in Figure 1 (barren and water are not further enumerated). Table 1, on the following page, summarizes the acreage and percentage each land use/land cover category represents.

Table 1 – Detailed 1995 Land Use/Land Cover

Land Cover Type	Acres	%
Agricultural	15,345.74	27.8
Agricultural Wetlands	388.35	0.7
Altered Lands	3.27	0.0
Brush Covered Field	1,345.96	2.4
Brush/Shrubland	3317.36	6.0
Commercial	275.41	0.5
Coniferous Forest	467.36	0.8
Coniferous Wooded Wetlands	4.72	0.0
Deciduous Forest	18,263.47	33.1
Deciduous Wooded Wetlands	5,879.73	10.6
Disturbed Wetlands	66.34	0.1
Exposed Rock	3.73	0.0
Industrial	103.86	0.2
Managed Wetland	27.12	0.0
Mining	344.38	0.6
Mixed Forest	528.99	1.0
Mixed Wooded Wetlands	161.24	0.3
Other Agriculture	595.53	1.1
Other Urban	724.09	1.3
Recreational Land	280.42	0.5
Residential	5,933.95	10.7
Residential, High Density	45.59	0.1
Transitional Areas	33.96	0.1
Transportation and Utilities	341.32	0.6
Water	183.08	0.3
Wetlands	568.32	1.2
Total	**55,233.26**	

Table 2– Population Change (1970 to 2000)

MUNICIPALITY	1970	1980	1990	2000	Change 1970-2000	% Change 1970-2000
East Amwell Township	2,568	3,468	4,332	4,455	1,887	73.5%
West Amwell Township	2,142	2,299	2,251	2,383	241	11.3%
Hillsborough Township	11,061	19,061	28,808	36,634	25,573	231.2%
Montgomery Township	6,353	7,360	9,612	17,481	11,128	175.2%
Hopewell Township	10,030	10,893	11,590	16,105	6,075	60.6%
Total	**34,124**	**45,061**	**58,583**	**79,058**	**44,934**	**131.7%**

While growth in the municipalities which share the Sourland Mountain region was significant between 1970 and 2000 (see Table 2), when the population rose from 34,124 to 79,058 (131.7%), it is clear from comparison of land use/land cover data for roughly the same period that growth occurred on the fringe of the study area and not on the mountain itself. Historical land cover interpreted from remotely sensed data reveals that in 1972, the Sourland Mountain region was dominated by forest and agricultural land cover types, representing nearly 83.5% of the study area's acreage. Wetlands comprised 14.2% of the region's land cover and urban land uses represented a mere 1.7%. In 1986, developed land uses began to appear in the region as more of New Jersey's population expanded into the western part of the state. Land dedicated to agriculture decreased by more than 2,000 acres, forested land declined by more than 2,500 acres and roughly 660 acres of wetlands were converted to other land uses. Simultaneously, urban land uses increased by 5,500 acres (574%).

Table 3 – Land Use/Land Cover Change (1972, 1986 and 1995)

LandUse/Land Cover Type	1972*		1986		1995		Change (1972 – 1995)	
	Acres	*%*	*Acres*	*%*	*Acres*	*%*	*Acres*	*%*
Agriculture	20,207.5	36.7	18,010.9	32.6	15,941.3	28.9	-4,266.2	-21.2
Barren Land	186.0	0.3	350.5	0.6	385.3	0.7	199.3	107.2
Forest	25,766.0	46.8	23,066.6	41.8	23,923.1	43.3	-1,842.9	-7.2
Urban	959.8	1.7	6,464.1	11.7	7,704.6	13.9	6,744.8	702.7
Water	59.9	0.1	178.3	0.3	183.1	0.3	123.2	205.7
Wetlands	7,826.4	14.2	7,162.9	13.0	7,095.8	12.8	-730.6	-9.3

*Acreages were approximated by multiplying the number of grids for each land use/land cover category by the grid size of 262'x262'.

The study area was marked by a decline in agricultural land uses (-21.2%) and a precipitous increase in urban land uses (702.7%) from 1972 to 1995. Roughly 4,266 acres of agricultural land was converted to other uses while urban land cover increased by 6,745 acres. Figure 3 reveals that the majority of conversion to urban land uses occurred in the valleys which surround the Sourland Mountain and not on the mountain proper; Montgomery, Hillsborough and

Hopewell Townships all show new residential growth that occurred post-1972. Figure 3 also illustrates that most conversion was from agricultural land directly to urban land. This is supported by the fact that forest cover declined a mere 7.2% (1,842 acres) from 1972 to 1995.

When considering changes in land use/land cover, it is important to consider factors that may not be apparent in the raw data; these factors are closely linked to the methods by which the data is compiled. As an example, what the data does not readily quantify is the replacement of old-growth forest with old fields in the forest category. Both are classified the same in a Level I land use/land cover scheme. Gross comparison of land cover characteristics, such as above, must be tempered with an understanding of their general nature. While useful for broad comparison, they cannot detail the true nature of change occurring at finer levels.

Forested Areas[1]

Including wooded wetlands, the study area has nearly 30,000 acres of forested areas. This represents 54% of the total acreage of the region and a significant portion of land cover. More than half (60.9%) is deciduous forest, which when combined with deciduous wooded wetlands, makes over 80% of the forested areas in the region deciduous in nature. Table 4 below lists the forest types depicted on Figure 4 and the percentage each type represents.

Table 4 – 1995 Forest Types

Forest Type	Acres	Percentage
Brush Covered Field	1,345.96	4.5
Brush/Shrubland	3,317.36	11.1
Coniferous Forest	467.36	1.6
Coniferous Wooded Wetlands	4.72	0.0
Deciduous Forest	18,263.47	60.9
Deciduous Wooded Wetlands	5,879.73	19.6
Mixed Forest	528.99	1.8
Mixed Wooded Wetlands	161.24	0.5
Total	**29,968.82**	

The forested areas of Sourland Mountain region play a vital role in many ecosystem functions, including:

- Habitat for threatened and endangered species;
- Breeding habitat for Neotropical migrant bird species
- Regulation of stream temperatures to support stability of streams and rivers;
- Provision of nutrients and woody debris to streams and rivers;
- Stabilization of steep slopes and reduction of erosion and sedimentation;
- Wooded wetlands act as headwaters to tributary streams of the Millstone and Delaware River watersheds;

[1] Forested areas data is taken from the New Jersey Department of Environmental. Protection 1995 Land Use/Land Cover data

- Conversion of carbon dioxide to oxygen;
- Dissipation of heat and provision of shade;
- Provision of riparian buffers;
- Reduction of urban heat island effects;
- Regulation of building temperatures and reduction of reliance on heating and cooling systems;
- Reduction of pollution;
- Reduction of noise pollution;
- Provision of privacy and screening;
- Stopover between and linkage to other ecosystems and greenways such as the Highlands, Pinelands, Duke Estate, Neshanic Greenway, D&R Greenway, and the Amwell and Hopewell valleys
- Enhancement of groundwater recharge capacities.

The most significant contiguous forest stand in the study area is found along the Sourland ridge stretching from Hillsborough and northern Montgomery into the southernmost part of East Amwell and the northern fringe of Hopewell (see Figure 5). At roughly 11,800 acres, this patch of forest represents the largest remaining contiguous forest in Central New Jersey (see Figure 6).

Another reasonably intact linear forest is found just west of the Route 31 corridor, which divides the forests of the Sourland ridge roughly in half. Bound by Rocktown-Lambertville Road to the north and Rock Road and County Route 518 to the South, this 1,200 acre, four thousand foot wide patch of forest is interrupted only by sparse residences until it intersects County Route 518 as it reaches to Lambertville City. (see Figure 7)

The forest found at Baldpate Mountain consists of roughly 1,500 acres of deciduous woodland. Although traversed by a utility right-of-way and home to an area of agriculture, this forest is uninterrupted by urban land uses. (see Figure 7)

The forests of the study area are characterized by a number of tree species that can be considered important, based on a 1990 study prepared by Douglas W. White, PhD of Rutgers University. The study, entitled "Woodlands of Hopewell Valley", highlighted the characteristics of forests in the northern half of the Township; most are within the study area. Ash, Tulip, Red Oak, Beech, White Oak, Hickory and Red Maple had the highest basal area, relative density and relative frequency (White, 1990). The importance of these species extends to other forested areas of the Sourland region.

Comparison of land use/land cover data from 1986 and 1995 shows that 683.8 acres of forest were converted to other land uses, primarily residential (66%, including other urban). Forest areas cleared for agriculture accounted for 12.8% (87.6 acres) of forest lost, while expansion of mining (10.4%) and industrial areas (3.6%) accounted for the majority of the remainder. Considering the amount of new forested areas since 1986, however, there was a net gain of 826 acres. Succession of crop and pastureland accounts for 90% (1,359 acres) of new forested areas identified in 1995. Surprisingly, conversion of residential and other urban land uses comprised 90.6 acres of new forest (6%).

Typically, forested areas converted to other land uses rarely revert to forest, especially when converted to residential uses. The only gain that can reasonably be expected, as seen in comparison of the 1986 and 1995 land use/land cover information, comes from succession of agricultural land. Most of the lands which reverted to forest cover were fields that were less than 25% brush covered. These lands could easily be tilled and reclaimed for agricultural purposes. This makes the perceived "gain" in forested land cover somewhat suspect, as these lands could have been reclaimed for agriculture in the year after the data was assembled.

Agricultural Lands[2]

In 1995, the study area had 15,941.3 acres of land categorized as agricultural in nature. This acreage represents 29% of the region. For the most part, these lands are located on the flanks of the Sourland ridge stretching into the Amwell and Hopewell valleys, as depicted on Figure 8. There are, however, areas of agriculture interspersed among forested areas on the Mountain itself.

Crop and pastureland represent nearly 95% of agricultural land in the Sourland region. The remaining categories of agricultural land cover are represented by orchards, vineyards and nurseries (230 acres) and other agriculture (602.4 acres). Other agricultural uses are characterized by confined feeding operations, experimental fields, horse farms and isolated dikes and access roads.

Reviewing land cover data from 1986 and 1995, 2,211 acres of agricultural land was converted to other land uses over the nine year period. The majority (62%) was converted to brush covered field and brush/shrubland, representative of cropland and pasture that went fallow for an extended period of time. New residential and other urban uses comprised 33% (730 acres) of agricultural land converted. New agricultural areas evident since 1986 amounted to 141 acres, composed primarily of conversion of brush/shrubland and deciduous forest (70.7% together) to cropland. There was, however, conversion of residential and recreational land to agricultural use, accounting for 11.4% and 5.7% respectively.

The agricultural lands which flank the Sourland Mountain play an important role as grassland habitat for breeding birds, including a number of endangered species (see Appendix 4). Much of the crop and pastureland of the Amwell and Hopewell valleys are hay and pasture ideal for birds. But the agricultural management of these fields is what ultimately determines their suitability as breeding grounds. Generally, hay or pasture which is mowed prior to mid-July is not suitable for breeding. Depending on weather, most farmers will harvest the first crop of hay well before mid-July, especially in years with generous precipitation in late spring.

Geology [ii]

The study area falls within the Piedmont physiographic province of New Jersey. The Sourland Mountain consists of bedrock formations which are severely limited in their ability to produce clean water. These bedrock formations, depicted on Figure 9, were deposited in a series of basins during the Triassic and Jurassic Ages, when violent volcanic activity shaped the Sourlands

[2] Agricultural lands data is taken from the New Jersey Department of Environmental Protection 1995 Land Use/Land Cover data

landscape. The sedimentary deposits of the Stockton, Passaic and Lockatong formations formed broad alluvial plains, which were reshaped when volcanic activity baked the sedimentary layers of shale and sandstone and erupted through the surface, forming the Diabase core of the Mountain.

The Stockton Formation, which occupies 2,679 acres or roughly 5 percent of the study area, is the oldest sedimentary deposit, consisting of sand, gravel and silt. The Lockatong Formation, consisting of fine grain silts, clays and sands were deposited over the Stockton Formation in lakebeds, and account for 12,632 acres, or roughly 23 percent of the study area. Later sedimentary deposits (Late Triassic-Early Jurassic) of fine grain sands, silts and clay deposited in lakes and mudflats were later cemented into the red to gray colored shales, siltstones, mudstones and sandstones of the Passaic Formation. The Passaic Formation occupies the largest area within the Sourland Mountain study area at 25,080 acres (45.4 percent of study area), and when combined with the Passaic Formation graybed (3,376 acres, or 6.1 percent of study area), Passaic bedrock accounts for over half of the study area.

The Diabase, which forms the hard rock core of the mountain, represent the youngest bedrock formation on the mountain, having intruded as magmas that produced dense, hard and poorly fractured crystalline Diabase and baked, or metamorphosed, the adjacent sediments in relatively close proximity.

The groundwater-bearing potential of these bedrock formations relates to their ability to store and transmit water, and is related to the extent of fractures, joints and bedding planes. Fracturing, generally limited to the weathered mantle that extends less than 100 feet below the ground surface, is a key determinant of the potential to yield groundwater. As compared to Jurrasic Diabase, the Passaic and Stockton Formations, with numerous fractures and fairly wide fracture spacing, have better potential to yield potable water supplies and to maintain base flow within the region. Conversely, the lack of significant fracturing in the Lockatong and Diabase formations limits their ability to store substantial groundwater. A detailed review of the water bearing capabilities of these bedrock units is contained in the Hydrogeology Report prepared by Matthew Mulhall, PG and Peter Demicco, PG.

Soils

Soils are formed by the weathering and break up of parent material (rock). They bear a strong relationship to the rock from which they are formed and are often times greatly influenced by this relationship, especially in the Sourland region. A variety of factors related to community development are limited by the soils present in the region. With their shallow depth to hard bedrock and presence of layers which restrict infiltration of precipitation, their properties must be considered carefully.

The soils of the Sourland Mountain region have significant limitations in terms of their agricultural suitability, depth to bedrock and seasonal high water and suitability for on-site disposal of effluent. All of these characteristics are related by way of soil associations, as mapped in the Soil Surveys published by the United States Department of Agriculture (USDA) Soil Conservation Service for the three counties in which the study area is located. In addition to

Soil Surveys, the USDA Natural Resources Conservation Service published digital soil surveys and supporting data tables known as Soil Survey Geographic (SSURGO) databases (see the table in Appendix 1 for SSURGO Soil Characteristics). This digital data, used to create the maps depicted in Figures 10 through 15, is based on the Soil Surveys of Somerset County, published in 1976, Hunterdon County, published in 1974 and Mercer County, published in 1972.

There are a number of different soil associations present in the Sourland Mountain region, each of which are categorized based on the parent material from which they were formed. They can be described as follows and are presented by county for the region:

Somerset County (Hillsborough and Montgomery Townships)[3]

Soils formed mainly in glacial till or material weathered from granitic gneiss, Diabase or basalt – The nearly level to very steep soils that make up these associations are dominantly gravelly, very stony, or rocky and are underlain by granitic gneiss, Diabase, or basalt bedrock. The depth to bedrock is mainly 4 or more feet. In some areas of the steep and very steep soils, outcrops of bedrock are common. The soils of these associations are on ridges and are mostly wooded.

Neshaminy-Mount Lucas-Amwell Association: gently sloping to very steep, deep, well drained to somewhat poorly drained, loamy, gravelly and very stony soils that have bedrock mainly below a depth of 4 feet. This association is found atop the Diabase formation in the Sourland Mountain and along the southern boundary with Mercer County.

Soils formed in material weathered mainly from shale, siltstone, or sandstone but partly from conglomerate and argillite- The nearly level to very steep soils that make up these associations formed mainly in material weathered from red shale. In places they formed in material weathered from sandstone, siltstone, argillite, or conglomerate. The soils are mainly nearly level to strongly sloping. They have a surface layer of silt loam. The main farming areas of Somerset County are in these associations.

Penn-Klinesville-Reaville Association: nearly level to very steep, moderately deep and shallow, well drained to somewhat poorly drained loamy and shaly soils underlain mainly by red shale. This association is found on the north and south flanks of the Sourland Mountain.

Royce-Penn-Klinesville Association: Gently sloping to very steep, deep to shallow, well-drained loamy and stony soils underlain mainly by red shale. This association is found adjacent to the Sourland Mountain, extending east into Hillsborough and Montgomery Townships.

Chalfont-Lehigh-Croton Association: Nearly level to steep, deep, poorly drained to moderately well-drained loamy and stony soils underlain mainly by argillite or metamorphosed shale; on uplands. This association is found atop the Lockatong and Stockton formations on the Sourland Mountain.

[3] "General Soil Map," Somerset County, New Jersey, prepared by the USDA Soil Conservation Service, 1975.

Hunterdon County (East and West Amwell Townships)[4]

Soils of the Highlands and Adjacent Part of Piedmont Plateau– On the adjacent part of the Plateau, the soils are mostly deep, gently sloping to moderately steep, gravelly, stony or rocky. Included are narrow areas of flood plains. Most of the Piedmont Plateau of the County is used for the production of general crops.

Washington-Berks-Athol Association: Deep and moderately deep, gently sloping to moderately steep, well-drained soils; on uplands. This association is found in the southern part of West Amwell Township along the border with Mercer County.

Soils of the Piedmont Plateau- The dominant soils of the Piedmont Plateau are moderately deep or deep over shale, sandstone, or argillite. Slopes are mostly gently rolling. Most of the soils are well drained but some range to poorly drained. Minor areas are underlain by Diabase rock. These areas are very stony.

Penn-Klinesville-Bucks Association: Shallow to deep, gently sloping to moderately steep, well-drained soils. This association is present in only a small portion of the study area immediately adjacent to the Amwell Valley and Neshanic River.

Penn-Bucks-Reaville Association: Moderately deep and deep, gently sloping to moderately steep, well-drained to somewhat poorly drained soils. This association is found at the northern fringe of the study area in West and East Amwell Townships, extending along the Alexauken Creek into Lambertville City.

Lehigh-Chalfont-Lawrenceville Association: Deep, nearly level to moderately steep, moderately well drained and somewhat poorly drained, non-stony to very stony soils. This association is located on the north and south flanks of the Sourland ridge.

Neshaminy-Mount Lucas-Legore Association: Deep, nearly level to very steep, well-drained to somewhat poorly drained, mostly very stony soils. This association is found atop the Diabase of the Sourland ridge.

Mercer County (Hopewell Township)[5]

Soils of the Northern Piedmont – In the part of the county that lies within the Northern Piedmont Lowland, the soils are dominantly silty and commonly are shaly or stony. Most of the soils are underlain by hard bedrock at a depth of 2 to 20 feet. Ground water is generally scarce in the five soils association of the Piedmont area. Ground water is stored in fractured zones of the rock, and in many places the supply is barely adequate for private wells.

Neshaminy-Mount Lucas-Lehigh Association: Mainly deep, well-drained to somewhat poorly drained, moderately sloping to steep, stony soils that have a silty subsoil and overlie Diabase; but partly moderately deep, nearly level, non-stony soils that overlie shale or siltstone. This

[4] "General Soil Map", Hunterdon County, New Jersey, prepared by the USDA Soil Conservation Service, 1973.
[5] "General Soil Map", Mercer County, New Jersey, prepared by the USDA Soil Conservation Service, 1970.

association is located atop the Diabase along the northern border of the Township with Hunterdon County.

Quakertown-Chalfont-Doylestown Association: Moderately deep to deep, well-drained to poorly drained, nearly level to moderately steep soils that have a silty subsoil; mainly over sandstone and argillite but partly over red shale and siltstone. This association is located on the north and south flanks of the Sourland ridge.

Bucks-Penn-Readington Association: Moderately deep and shallow, well-drained and moderately well drained, gently undulating or gently sloping soils that have a silty sub-soil; over red shale or siltstone. This association is found between Baldpate Mountain and the border of the Township with Hunterdon County.

Soil Characteristics

Agricultural Suitability

As discussed in the section of this Natural Resource Inventory detailing the land use/land cover, roughly 30% of the study area is devoted to active agricultural land uses. This is not surprising given the fact that the region is characterized by soils uniquely suited to agricultural production.

The predominance of highly capable agricultural soils throughout the study area includes prime soils, statewide important soils and soils of local importance. The following descriptions of prime farmlands, soils of statewide importance and farmland of local importance are taken directly from the "New Jersey Important Farmlands Inventory", prepared by the State Agriculture Development Committee in 1990. Not included in this description is the category for unique farmlands, the generally poorly drained soils used for specialty crops such as cranberries and blueberries, which do not occur in the study area.

Prime Farmlands **-** Prime Farmlands include all those soils in Land Capability Class I and selected soils from Land Capability Class II. Prime Farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber and oilseed crops and is also available for these uses. It has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when treated and managed according to acceptable farming methods. Prime Farmlands are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding.

Soils of Statewide Importance - Farmlands of statewide importance include those soils in Land Capability Classes II and III that do not meet the criteria as Prime Farmland. These soils are nearly Prime Farmland and economically produce high yields of crops when treated and managed according to acceptable farming methods. Some may produce yields as high as Prime Farmland if conditions are favorable.

Farmland of Local Importance - Farmland of local importance includes those soils that are not prime or statewide importance and are used for the production of high value food, fiber or horticultural crops.

Prime agricultural soils comprise 20.3% (11,236.3 acres) of the study area. While most are located in Hopewell Township, there are additional pockets of prime soils in all of the municipalities sharing the region (see Figure 10). Statewide important soils make up the majority (38.4 % or 21,207.1 acres) of agriculturally productive soils in the region and have just 153 less acres than soils not classified as agriculturally productive, which represent 38.7% of the study area (21,360.5 acres). While most of the prime agricultural soils are located closer to the Amwell and Hopewell valleys, the statewide important soils of the study area are primarily concentrated adjacent to the Sourland Ridge. The baking of the shale which resulted from the intruding Diabase and weathering of both the Passaic and Lockatong formations produced large areas of soils suitable for agricultural production. Farmland of local importance makes up a mere 2.6% (1,429.9 acres) of the study area. They are interspersed and adjacent to areas of prime and statewide important soils.

On-Site Disposal of Effluent

With the adoption of *N.J.A.C.* 7:9A "Standards for Individual Subsurface Sewage Disposal Systems" in 1999, the New Jersey Department of Environmental Protection (NJDEP) revised their methods for classifying soils based on their suitability to dispose of effluent via a septic system and the appropriate type of system to be used given certain limitations. In the absence of detailed on-site soil investigation, the Soil Survey mapping is used to determine the location of soil series, and the standards specify the types of limiting zones that may be present and the type of system to be used, if any. Figure 11 shows the soils of study area as classified by Appendix D of *N.J.A.C.* 7:9A; Table 4, on the following page, lists the type of septic system permitted given the suitability class. Septic system types include conventional systems, soil replacement bottom-lined systems, soil replacement fill-enclosed systems, mound systems and mounded soil replacement systems.

Table 5 – N.J.A.C. 7:9A Limiting Zones

Type of Limiting Zone	Depth[2], ft.	Suitability Class	Type of Installation Permitted[3]
Fracture Rock or Excessively Coarse Substrata	>5 0-5	I IISc	C, (SRB, SRE, M, MSR) SRE, M, (MSR)
Massive Rock Hydraulically Restrictive Substratum	>9 4-9 <4	I IISr IIISr	C, (SRB, SRE, M, MSR) M, (MSR) UNSUITABLE
Hydraulically Restrictive Horizon, Permeable Substratum	>9 4-9 <4	I IIHr IIIHr	C, (SRB, SRE, M, MSR) SRB, SRE, M, (MSR) SRB, SRE, (MSR)
Excessively Coarse Horizon	>5 0-5	I IIHc	C, (SRB, SRE, M, MSR) SRE, M, (MSR)
Zone of Saturation, Regional	>5 2-5 <5	I IIWr IIIWr	C, (SRB, SRE, M, MSR) M, (MSR) UNSUITABLE
Zone of Saturation, Perched	>5 2-5 <5	I IIWp IIIWp	C, (SRB, SRE, M, MSR) C[4], (SRB, SRE, M, MSR) C[4], (SRB, SRE, M, MSR)

C = Conventional Installation
SRB = Soil Replacement, Bottom-lined Installation
SRE = Soil Replacement, Fill-enclosed Installation
M = Mound Installation
MSR = Mounded Soil Replacement Installation1
(1) Mounded soil replacement systems are generally required only in cases where several limiting zones are present as, for example, in compound soil suitability classes such as IIScWr, IIIHr (IISr) or IIIHr(IIWr).
(2) Depth is measured from the existing ground surface to the top of the limiting zone. In the case of disturbed ground, the depth to the limiting zone shall be measured from the pre-existing natural ground surface, identified as prescribed in N.J.A.C. 7:9A-5.10(c), or the existing ground surface, whichever is lowest.
(3) Installations shown in parentheses are allowed but are generally not the most cost-effective type of installation for the soil suitability class unless other soil limitations are present.
(4) An interceptor drain or other means of removing the perched zone of saturation is required. Note: In soils with a compound soil suitability class, where more than one limiting zone is present in the soil, a disposal field installation shall not be approved unless the type of installation proposed is listed in Table 10.1 as an acceptable option for each of the soil suitability classes which apply.

The 1999 standards adopted by the Department indicate certain soils with limiting zones that are unsuitable for any type of septic system installation. A number of these soil types are present in the study area and are mapped in Figure 12. According to *N.J.A.C* 7:9A approximately 46.2% (25,495.9 acres) of the study area could have soils unsuitable for any type of septic system installation. These generally coincide with soils underlain by the baked margins of the Passaic formation. Interestingly, none of these soils types are immediately underlain by the Diabase itself.

Depth to Bedrock

Depth to bedrock is one factor which affects a soils' ability to process septic effluent via a septic system. Generally the shallower the depth to bedrock, the less soil is present to properly treat human waste. Excluding mounded systems, a four foot zone of treatment is required to propertly treat septic effluent.

Figure 13 depicts the depth to bedrock for soils in the study area, as classified in the SSURGO database from the USDA NRCS (see table in Appendix 1 for SSURGO Soil Characteristics). The majority (68%) of soils in the region have a depth to bedrock between 40 and 60 inches, while 18% have depths 40 inches or less and the remainder (14%) have depths to bedrock 48 to 99 inches and 60 inches and greater. Many of the categorizations in the SSURGO database exhibit great variety, where the range presented could be part of another range based on site specific investigation.

Depth to bedrock for soils along the Sourland ridge itself is generally 48 to 60 inches and 48 to 99 inches. This is characteristic of soils underlain by Diabase. The soils which immediately straddle the ridge, corresponding to those underlain by the baked margins of the Passaic formation, have depths to bedrock of at least 40 inches, with pockets of soils exhibiting ranges from 20 to 40 inches. Many of the soils on the fringe of the study area have depth to bedrock ranging from 20 to 40 inches, with the majority of soils with shallow depths to bedrock underlain by the Passaic formation.

Depth to Seasonal High Water

Shallow depth to seasonal high water presents numerous limitations for development, most notably installation and maintenance of septic systems. Even with soil replacement and other engineering measures, septic systems placed in high water tables have the potential to pollute groundwater. When soils exhibiting shallow depths to seasonal high water are located adjacent to streams, there is also the potential for surface water contamination in periods of flooding. If a system is maintained improperly and ceases to function, effluent from the leach field that rises to the surface can be carried off in surface water. Even in periods when flooding is not prevalent; a failing septic system can introduce surface contamination into surface waters.

Shallow seasonal high water tables, while presenting limitations for development, also support diverse plant and wildlife communities. A majority of soils with depths to seasonal high water less than 4 feet, exhibiting both apparent and perched water tables, coincide with stream corridors and their associated wetlands or are located on the Sourland Mountain. Moderate or shallow depth to seasonal high water are good indicators of lands which deserve further study, perhaps warranting protection to limit destruction of private property and fostering of diverse plant and animal communities that may support critical habitat for threatened and endangered species.

Figure 14 depicts depth to seasonal high water for the soils in the study area (see table in Appendix 1 for SSURGO Soil Characteristics). Depth to seasonal high water indicates the highest level below the surface that groundwater reaches in most years, typically occurring between October and June, with variations in the length of time dependent on soil type. Those soils with depth to seasonal high water of 4 feet or less exhibit two water table types; apparent and perched. An apparent water table is illustrated by water standing in a freshly dug hole. These soil types generally coincide with stream beds and wetland areas, but do occur in other locations spread throughout the study area. Of the soils with depth to seasonal high water of 4 feet or less, 10.6% (5,858.4 acres) are classified as having an apparent water table. A perched water table is characterized by water standing above an unsaturated zone in the soil horizon, often obstructed by an impermeable or hydraulically restrictive layer within the profile. While a few of these soil types coincide with wetland areas, most are located atop and along the flanks of the Sourland Mountain. These soil types represent 48.5% (26,774.3 acres) of the soils in the study area with depths to seasonal high water of 4 feet or less. The majority of soils with a perched water table exhibit standing water above the hydraulically restrictive zone from November until March.

Of the soils in the study area, the majority (67.6%) have generally shallow depths to seasonal high water, ranging from 0 to 3 feet. Of these soils, only 36.6% exhibit depth to seasonal high water of 1.5 feet or less. Soil types with generally shallow depth to seasonal high water are almost exclusively located atop or on the flanks of the Sourland Mountain, along stream beds or in isolated pockets in Hopewell Township. There are, however, isolated pockets north of the Sourland ridge in East and West Amwell Townships. A number of these seasonally high water tables support wetland systems associated with river and stream systems, deciduous wooded wetlands which act as headwaters for numerous streams and diverse vernal or emergent ecosystems present in the Sourland Mountain region and along rivers and streams.

A mere 0.2% (106.9 acres) of soils in the study area possess what could be characterized as moderate depth to seasonal high water, generally around 4 feet. These soils are primarily located north of Baldpate Mountain (on permanently preserved parkland), with small pockets east of Hopewell Borough and in the eastern part of the study area in Montgomery. As compared to soils exhibiting shallow depths to seasonal high water, soils with generally moderate depths have only a few limitations for community development factors. They can have an impact on the installation of foundations and septic systems, depending on site specific conditions and the duration of the high water table.

The remainder of soils, comprising 32.2% of the study area (17,795.7 acres), exhibit generally deep depths to seasonal high water at 6 feet. These soil types are generally found along the north and south fringes of the study area. They are interlaced with soils exhibiting generally shallow depth to seasonal high water, associated primarily with stream corridors and wetland areas. Most of the soils with generally deep depth to seasonal high water coincide with agriculturally productive soils of prime classification, some of which are currently in agricultural production. The soils in this category are least susceptible to potential problems related to development and any of the minor limitations that may be present can be overcome.

Highly Erodible Lands

The United States Department of Agriculture, Natural Resources Conservation Service rates soils based on their potential for erosion by wind and water. This is referred to as the "Highly Erodible Lands" class. None of the soils in the region are susceptible to erosion by wind. With respect to water, there are soils in the region rated for erodibility, as depicted in Figure 15 (see Table 11 in Appendix II for SSURGO Soil Characteristics). These soil types are discussed in detail below.

Of the soils in the study area, 25.7% (14,183.4 acres) are rated as "Highly Erodible Land Class" in the SSURGO database. This indicates that the soil will erode when exposed to water, such as heavy rain or surface water runoff. A comparison of the location of "Highly Erodible Lands" and the steep slope mapping in Figure 22 shows that some of the "Highly Erodible Lands" are in areas of slope greater than 15%. Most of the soils in this category are of the Birdsboro, Chalfont, Doylestown, Hazleton, Klinesville, Lawrenceville, Legore, Lehigh, Mount Lucas, Neshaminy, Penn, Quakertown, Readington and Reaville series. There are a number of soils designated as "Highly Erodible Lands", however, that are not located in areas of slopes greater than 15%.

Of the remaining soils in the region, 75% (15,588 acres) are categorized as "Potentially Highly Erodible". While these soils do not have the component of slope that "Highly Erodible Lands" do, they possess similar texture and surface properties and will experience erosion from heavy rain and swift moving surface water. This class is comprised of the entire spectrum of soils in the study area and are scattered throughout region. Only 4.9% (2,702.3 acres) are classified as "Not Highly Erodible", comprised of the Birdsboro, Bowmanville, Bucks, Penn, Pope, Rowland and Tioga series primarily located along the banks of streams and rivers.

Soils in the "Highly Erodible Lands" class require careful management in farming, logging and development. The USDA, under the "Highly Erodible Land and Wetland Conservation Act" restricts participation in certain funding programs for those producing an agricultural commodity on highly erodible land. In order to address concerns of farming on highly erodible lands, mitigation in the form of conservation plans and conservation systems can be implemented. In the course of permitted development, disturbance of highly erodible soils should be avoided unless adequate measures can be implemented to assure that erosion and soil loss will be minimized. Although some equate highly erodible lands with areas of steep slope, there are areas of highly erodible lands that do not coincide with slopes greater than 15%. These areas must be afforded protection, as minimizing soil loss will help eliminate potential surface water quality impairment while maximizing groundwater and aquifer recharge. This is especially important atop the Sourland Mountain, where all streams are headwater streams.

Surface Waters and Subwatersheds

The Stony Brook is the principal surface water body in Sourland region, ultimately receiving drainage from 22.5% of the land within the study area. Table 5 lists the streams and rivers of study area with their length, as well as the percentage of total stream length in the region they represent; surface waters, including lakes, are depicted on Figure 16.

Table 6 – Streams and Rivers

Stream or River Name	Designated C-1	Nominated C-1	Length (miles)	%
Alexauken Creek	Yes	N/A	13.9	10.4
Back Brook	No	Public	11.4	8.5
Baldwins Creek	No	Public	3.3	2.5
Bedens Brook	No	NJDEP, Public	7.3	5.5
Cat Tail Brook	No	Public	1.5	1.1
Cruser Brook	No	Public	1.2	0.9
D&R Canal	No	Public	2.1	1.6
Fiddler's Creek	No	NJDEP, Public	0.7	0.5
Jacob's Creek	No	NJDEP, Public	5.0	3.7
Moore Creek	No	NJDEP, Public	19.9	14.9
Neshanic River	No	Public	15.3	11.5
Peter's Brook	No	Public	2.0	1.5
Pleasant Run	No	Public	1.9	1.4
Roaring Brook	No	Public	2.0	1.5
Rock Brook	No	Public	10.7	8.0
Royce Brook	No	NJDEP, Public	0.2	0.1
Stony Brook	No	NJDEP, Public	27.9	20.9
Swan Creek	No	NJDEP, Public	5.6	4.2
Woodsville Brook	No	Public	1.7	1.3
Total			**133.6**	

Surface waters can be categorized by their order. Surface waters of first order are considered headwaters, the origin of all other surface waters of higher order. Of the surface waters in the region, 67% (89.5 miles) are first order. The vast majority of these surface waters originate on the Sourland Mountain, making it a significant headwaters region. Of the remaining surface water courses, 21.2% (28.3 miles) are second order, 9.7% (13 miles) are third order and 2.1% (2.8 miles) are fourth order waterways. Protection of lower order surface waters assumes increasing importance as downstream waters become degraded.

Figure 17 depicts subwatersheds of the study area, all draining to two main watersheds, the Delaware River and the Raritan River. The major drainage basins divide the region with roughly 1/3 draining to the Delaware and 2/3 draining to the Raritan. The Sourland ridge again divides these two major drainage areas, with the streams on the north side of the ridge draining mostly east and west then flowing north off the mountain and the streams on the south draining mostly east and west then flowing south off the mountain. Some of the watercourses simply drain due south, north, east or west with no other patterns evident. For the most part, streams of the subwatersheds exhibit dendritic (branching and treelike) patterns, with the exception of the Stony Brook, which can be best described as a hybrid between a trellis and dendritic drainage pattern. A number of the first order tributaries flow into the main stem as right angles, characteristic of a trellis pattern. The subwatersheds are smaller drainage basins within larger hydrological units. Water quality impacts are often easier to track in subwatersheds, especially those related to nonpoint source pollution. Due to their smaller size, it is easier to assess the location of potential pollution sources and determine impacts they may have on water quality.

According to data from the New Jersey Department of Environmental Protection, there are 22 HUC 14 (Hydrologic Unit Code) drainage areas within the study area that are part of the Delaware River drainage basin and 15 within the Raritan River Basin. Table 7 lists the HUC 14's within the study area, the watercourses within them and the HUC14 acreage.

Table 7 – HUC14 Subwatersheds

Subwatershed Name	Hydrologic Unit Code (HUC)	Area (Acres)	%
Back Brook (Raritan)	02030105030050	3,590.0	6.5
Neshanic River(Raritan)	02030105030060	5,421.3	9.8
Pleasant Run(Raritan)	02030105040010	765.4	1.4
Stony Brook(Raritan)	02030105090010	3,561.4	6.4
Stony Brook(Raritan)	02030105090020	6,174.2	11.2
Stony Brook(Raritan)	02030105090030	2,684.1	4.9
Baldwins Creek(Raritan)	02030105090040	1,265.9	2.3
Stony Brook(Raritan)	02030105090050	9.2	0.0
Beden Brook(Raritan)	02030105110040	3,880.8	7.0
Beden Brook(Raritan)	02030105110050	376.6	0.7
Rock Brook(Raritan)	02030105110060	3,875.7	7.0
Back Brook(Raritan)	02030105110070	490.4	3.2
Rock Brook(Raritan)	02030105110070	1,266.8	2.3
Pike Run(Raritan)	02030105110080	821.0	1.5
Cruser Brook(Raritan)	02030105110090	1,833.7	3.3
Back Brook(Raritan)	02030105110100	957.6	1.7
Royce Brook(Raritan)	02030105110150	328.8	0.6
Alexauken Creek(Delaware)	02030105110010	4,021.6	7.3
Alexauken Creek(Delaware)	02030105110020	1,042.6	1.9
D&R Canal(Delaware)	02030105110030	912.8	6.0
Swan Creek(Delaware)	02030105110030	2,404.7	4.4
Moore Creek(Delaware)	02030105110040	6,537.5	11.8
Fiddler's Creek(Delaware)	02030105110050	1,155.6	2.1
Jacob's Creek(Delaware)	02030105110060	1,856.0	3.4
Total		**55,233.7**	

Surface Water Quality

Preserving and enhancing surface water quality is of great importance for preserving the environmental health of water bodies as well as the scenic and recreational opportunities that the region's streams, rivers and lakes provide. The primary method of classifying water quality for streams and rivers in New Jersey is offered in the New Jersey Department of Environmental Protection (NJDEP), Division of Environmental Planning "Surface Water Quality Standards" (N.J.A.C 7:9B). Through these statewide standards, a regulatory framework is established and management policies are implemented based on the designation of streams as FW1 and FW2, Category 1 and 2 and either trout-producing, trout-maintenance or non-trout waters.

According to NJDEP, all surface waters within the study area are currently classified as "FW2". "FW2" *means the general surface water classification applied to those fresh waters that are not designated as FW1 or Pinelands Waters* [1]. As a frame of reference, "FW1" *means those fresh waters, as designated in N.J.A.C. 7:9B-1.15(h) Table 6, that are to be maintained in their natural state of quality (set aside for posterity) and not subjected to any man-made wastewater discharges or increases in runoff from anthropogenic activities. These waters are set aside for posterity because of their clarity, color, scenic setting, other characteristic or aesthetic value, unique ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resource(s).*[iii] Possible uses described for FW2 waters include:

1. Maintenance, migration and propagation of the natural and established biota;
2. Primary and secondary contact recreation;
3. Industrial and agricultural water supply;
4. Public potable water supply after conventional filtration treatment (a series of processes including filtration, flocculation, coagulation, and sedimentation, resulting in substantial particulate removal but no consistent removal of chemical constituents) and disinfection; and
5. Any other reasonable uses.

In addition to the above classification and for purposes of implementing regulatory policy, surface waters are further categorized by NJDEP as either "Category 1" or "Category 2". Category 1 waters "*means those waters designated in the tables in N.J.A.C. 7:9B-1.15(c) through (h), for purposes of implementing the antidegradation policies set forth at N.J.A.C. 7:9B-1.5(d), for protection from measurable changes in water quality characteristics because of their clarity, color, scenic setting, other characteristics of aesthetic value, exceptional ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resource(s). These waters may include, but are not limited to:*

1. *Waters originating wholly within Federal, interstate, State, county, or municipal parks, forests, fish and wildlife lands, and other special holdings that have not been designated as FW1 at N.J.A.C. 7:9B-1.15(h) Table 6;*
2. *Waters classified at N.J.A.C. 7:9B-1.15(c) through (g) as FW2 trout production waters and their tributaries;*
3. *Surface waters classified in this subchapter as FW2 trout maintenance or FW2 nontrout that are upstream of waters classified in this subchapter as FW2 trout production;*
4. *Shellfish waters of exceptional resource value; or*
5. *Other waters and their tributaries that flow through, or border, Federal, State, county, or municipal parks, forests, fish and wildlife lands, and other special holdings."* [iv]

Category 2 waters "*means those waters not designated as Outstanding National Resource Waters or Category One at N.J.A.C. 7:9B-1.15 for purposes of implementing the antidegradation policies set forth at N.J.A.C. 7:9B-1.5(d)."* [v]

According to NJDEP, with the exception of Alexauken Creek, all surface waters within the study area are classified as Category 2 waters and fall under the general anti-degradation policies of the regulations as well as those specified for Category 2 waters. General anti-degradation policies seek to protect waterways from decline in quality while protecting the designated uses set forth. In addition to general policies, where water quality exceeds levels necessary to support the designated uses, that level shall be maintained unless deterioration would accomplish important social or economic goals. Further categorization of surface water is accomplished through designation as trout-producing, trout maintenance or non-trout waters; all surface waters of the Sourland Mountain region are classified as non-trout waters with the exception of Alexauken Creek, Moore Creek and Fiddler's Creek, which are classified as trout maintenance waters. Trout production waters are those that are home to breeding populations of native trout while trout maintenance waters are those that are home to native populations of trout, although trout do not breed there.

With the exception of Alexauken Creek, none of the surface waters within the study area are currently afforded the protection of Category 1 designation. NJDEP is proposing, however, to reclassify certain waters within the State, some of which are within the study area (see Table 6). Reclassification is based on criteria established by the Department, including surface waters within HUC14's (hydrological unit code) with less than 10% impervious cover draining to water supply areas, surface waters draining to the Delaware and Raritan Canal and certain lands identified as ecologically significant by various departments and agencies with the state and Federal government. Included in the nominations are Fiddler's Creek, Jacob's Creek, Moore Creek, Swan Creek, Beden Brook, Royce Brook and Stony Brook. The NJDEP also solicited nominations for reclassification to Category 1 designation from the public and other agencies.

The Surface Water Quality Standards adopted by NJDEP in 2003 also established strict guidelines for the presence of numerous contaminants, both man-made and naturally occurring. Included in these categories are items such as fecal coliform, enterococci, dissolved oxygen, floating colloidal solids, petroleum hydrocarbons, phosphorus, suspended solids, total dissolved solids, sulfates and taste and odor producing substances. Also important, especially to future potential areas of Category 1 waters are alterations to temperature and the addition of toxic substances.

AMNET Biological Monitoring and Water Quality

The Bureau of Freshwater Biological Monitoring, a division of the NJDEP, currently conducts monitoring of freshwater rivers and streams in New Jersey. The Ambient Biomonitoring Network (AMNET), NJDEP's monitoring program, has an average of 165 monitoring sites in the major drainage basins of the State, with 15 stations located within or in close proximity to the study area.

NJDEP's AMNET monitoring program focuses on populations of macroinvertebrates (invertebrates which can be seen without the aid of a hand lens or microscope) present in freshwaters. These biotic communities, which are mainly stationary and cost effective to monitor, integrate the effects of changes in water quality into their life cycle, providing effective indicators of change over time. AMNET has fifteen monitoring stations for waterways in the Sourland region, providing data from 1993-1994 and 1998-1999. Figure 18 depicts the location of these monitoring stations, with two along Alexauken Creek, two along Stony Brook, two along Moore Creek, one along Jacob's Creek, two along Rock Brook, one along Beden Brook, two along Alexauken Creek, one along Swan Creek, two along Back Brook and one along the Neshanic River. This distribution of locations, along virtually every waterway in the region, provides a valuable tool for assessing changes in water quality. With additional sampling planned for 2003, a comprehensive means to monitor changes over time will be in place.

The AMNET data for the study area shows that for the 1998-1999 monitoring round, seven of the fifteen sites depicted on Figure 18 had non-impaired benthic communities. This is an improvement over the six non-impaired communities identified when the first round of sampling was completed in 1993. Seven of the remaining sites showed moderate impairment, with ratings ranging from 12 to 18.

A number of sites showed improvement over the first round of sampling. This included one site along the Back Brook, (AN0334), a site along the Neshanic (Furman's Brook – AN0336) a site along Rock Brook (AN0399), a site along Beden Brook (AN0398), a site along Jacob's Creek and a site along Moore Creek (AN0101). The sites at the Neshanic (Furman's Brook) and Moore Creek improved to such a degree that their rating was changed to indicate no impairment. But along with improvement at a number of stations, some stations showed a decline. Station AN0390 along the Stony Brook declined from a rating of 24 to a rating of 15, showing moderate impairment in the second round of monitoring. Station AN0100 along Moore Creek declined from a rating of 27 to a rating of 24 but maintained a no impairment rating. Station AN 0099 along Swan Creek declined from a rating of 21 to a rating of 18, continuing to show moderate signs of impairment. The data for each AMNET site in the region is indicated in the table on the following page.

Table 8 – AMNET Biological Monitoring Sites

Site #	Water Course	1992 Score	1992 Rating	1998 Score	1998 Rating	Habitat Score
AN0097	Alexauken Ck	24	NONE	24	NONE	999
AN0096	Alexauken Ck	27	NONE	27	NONE	999
AN0098	Alexauken Ck	30	NONE	30	NONE	999
AN0334	Back Bk	15	MODERATE	18	MODERATE	120
AN0335	Back Bk	21	MODERATE	12	MODERATE	118
AN0336	Furmans Bk	18	MODERATE	27	NONE	161
AN0390	Stony Bk	24	NONE	15	MODERATE	157
AN0399	Rock Bk	12	MODERATE	18	MODERATE	161
AN0400	Rock Bk	21	MODERATE	99	NOSAMPLE	999
AN0398	Bedens Bk	15	MODERATE	21	MODERATE	126
AN0100	Moores Ck	27	NONE	24	NONE	999
AN0101	Moores Ck	18	MODERATE	27	NONE	999
AN0099	Swan Ck	21	MODERATE	18	MODERATE	999
AN0102	Jacobs Ck	24	NONE	27	NONE	999
AN0391	Stony Bk	12	MODERATE	12	MODERATE	135

Note: Impairment rating is out of a possible 30, habitat rating is out of a possible 200.

The data for AMNET monitoring also includes an assessment of habitat within a 100-200 foot radius of the sampling site. This assessment, available only in the 1998 data, provides information on in-stream substrate, channel morphology, bank structural features and riparian vegetation. Habitat assessment is done independent of biological monitoring and did not factor into the final impairment score for the monitoring sites for the region. Of the 15 sites in the region, 8 were not rated for habitat. Of the 7 sites remaining, the Neshanic (Furman's Brook), Stony Brook and Rock Brook sites all scored in the optimal habitat range (160-200) while the Back Brook, Beden Brook and one Stony Brook site scored in the range of sub-optimal habitat (110-159).

With data collected on a five year cycle, the AMNET monitoring program will continue to provide useful data for assessing the health of waterways statewide. With samples to be collected in 2004 and 2005, determining the health of surface waters through comparative assessment of macroinvertebrate communities can continue. Once this data is released from the NJDEP, further changes in water quality should be assessed and the communities sharing the region should determine if regulatory guidance at the local level is appropriate. As the main impact to water quality comes from surface runoff related to increased impervious surface, examination of impervious cover limitations would be an appropriate first step. This could be followed by creation of requirements for water quality buffers, water quality treatment methods (bio-retention and filtering basins as opposed to detention basins) and stricter requirements for infiltration; the latter would ultimately eliminate new surface runoff sources. With the NJDEP's proposal to reclassify a majority of the surface waters in the Sourland region as Category 1, the special resource area requirements would be implemented. This will no doubt makes strides to improving surface water quality as buffers are created.

Wetlands

Wetland habitats generally occur between well-drained upland areas that rarely receive floodwater and low-lying, permanently flooded waters of lakes or streams. Wetlands characteristically include swamps, bogs, marshes and bottomland areas. Although they usually lie along rivers and lakes, wetlands may occur on slopes where they are associated with groundwater seeps or in areas of a perched water table, as is typical on the Sourland Mountain. Wetlands depicted on Figure 19 are taken from the New Jersey Department of Environmental Protection's Land Use/Land Cover information from 1995. Wetland features from this data set were derived from the Freshwater Wetlands (FWW) data from the New Jersey Freshwater Wetlands Mapping Project, which was combined with the 1986 Integrated Terrain Unit Mapping (ITUM) to create the 1986 Land Use/Land Cover data.

The NJDEP wetland mapping in Figure 19 indicates that 7,068.7 acres of wetlands exist in study area. The predominant wetland type is deciduous wooded, comprising just over 83% of the total acreage of wetlands at 5,879.7 acres. While a number of these wooded wetland areas are located along stream corridors, a large expanse is present along the Sourland ridge. Deciduous scrub/shrub and herbaceous wetlands (aggregated as "wetlands") represent the second largest type of wetland, comprising 8% (568.3 acres) of all wetland areas. Deciduous scrub/shrub wetlands are typically successional areas where vegetation is in early stages of growth. Left untouched, these areas will eventually likely become deciduous wooded wetland areas. Herbaceous wetlands are typically emergent-like habitats located along stream corridors where vegetation can be frequently flooded and run down by moving water. In late summer, vegetation is typically stable and hardy, maintaining a vegetative state below scrub/shrub. Both of these wetland types are primarily located along water courses, but are present along the fringes of larger areas of deciduous wooded wetlands spread across the study area.

Agricultural wetlands represent 5.5% (388.4 acres) of those in the region. Agricultural wetlands are wetland areas that have been modified for crop production, generally by the installation of drainage features such as ditches or tiles. When drainage features are removed and the land is allowed to fall into succession, these areas will generally revert to wetlands. Agricultural wetlands are typically located at the edge of existing wetland areas which abut field fringes. They are located throughout the Sourland Mountain region, but are mainly focused on the flanks of the ridge itself.

Mixed wooded (2.3% or 161.2 acres) and coniferous wooded (0.1% or 4.72 acres) comprise the remaining wetland areas found in the Sourland Mountain region. Mixed wooded wetlands are found atop the Sourland ridge, along the flanks of the ridge and on the fringe of the study area. The majority is in one location at the fringe of the study area southeast of Hopewell Borough in Hopewell Township. The lone patch of coniferous wooded wetland in the study area is located north of Hopewell-Amwell Road, northeast of Hopewell Borough.

Six general wetland types are identified in Figure 19 and listed in Table 7 below.

Table 9 – Wetland Types

Type	Acres	Percentage
Agricultural Wetlands	388.35	5.5
Coniferous Wooded Wetlands	4.72	0.1
Deciduous Wooded Wetlands	5,879.73	83.2
Disturbed Wetlands	66.34	0.9
Mixed Wooded Wetlands	161.24	2.3
Wetlands	568.32	8.0
Total	**7,068.7**	

A majority of the wetlands found in the region are designated as Palustrine and can be described as marshy, boggy or swampy. Types of Palustrine wetlands are further defined according to the dominant types of vegetation found in each, or according to the form and composition of the substrate material of each wetland. The Palustrine Forested Broad Leaf Deciduous wetland, for example, is at least 50% forested and forested predominately with deciduous trees having broad leaves, such as oak or maple. The other classifications of palustrine wetlands include emergent, open water and scrub/shrub broad leaved deciduous. The open water classification refers to wetland areas that appear wet, as in ponded areas. The emergent designation means that most of the characteristic vegetation is rooted in shallow water. Small trees and shrubs dominate the scrub/shrub type of wetland.

The importance of wetlands is multi-faceted. They serve as aquifer recharge areas and as areas that trap and filter pollutants through natural bio-chemical processes. The filtering capabilities of wetlands are particularly useful along waterways where protection of existing water quality is desirable. Wetlands in these areas may serve as a buffer to harmful nonpoint source pollutants.

Wetlands play a particularly valuable role on the Sourland Mountain, acting as headwaters to all of the water courses in the study area. As none of the streams which flow off the mountain are classified as trout-producing or trout maintenance, many of the wetlands in this area are not classified as being exceptional in value. There are, however, wetlands classified as exceptional due to the presence of threatened or endangered species. In addition to acting as headwaters, the wetland systems of the Sourland Mountain capture and retain precipitation, slowly releasing it into the ground and recharging aquifers. This is critical, as recharge on the mountain is extremely low.

Although State regulations afford some protection to wetlands, they do not prevent destruction or disturbance per se, and it is prudent to consider additional environmental resource protection strategies that can build upon these State protections. More and more, the importance of wetlands in flood control and water quality is becoming known.

Floodplains

The Federal Emergency Management Agency (FEMA) has prepared maps of the 100-year floodplain found along a number of the streams and rivers in the study area, as taken from the Q3 Flood Digital database and depicted on Figure 20. This mapping is prepared to provide information to homeowners, floodplain managers, engineers and flood insurance providers on the flooding risks associated with the location of dwellings and structures. It should be noted that the digital floodplain data that FEMA provides was created by digitizing the existing Flood Insurance Rate Maps (FIRM) with varying scales. In most cases, the data is distorted to varying degrees and is useful only for generalized floodplain location and magnitude.

All five communities in the study area participate in the National Flood Insurance Program (NFIP), whereby they have adopted standards regarding development in the floodplain. A Flood Hazard Study initiated each community's participation in the Program; all have implemented development regulations to prohibit or limit development in the floodplain to reduce the risk of flood damage and protect public safety.

FEMA requires all persons with improved property within a special flood hazard area as certified by the Township Flood Search Official and shown on the Flood Insurance Rate Maps (FIRM) purchase flood insurance. They recommend that even those not directly in a flood hazard area purchase insurance, as flood damage can occur outside the flood hazard areas as well.

The mapping of floodplains provided by FEMA carries a number of different designations. The 100-year floodplain is delineated for most streams though some do not have base flood elevations (BFE's) determined, as indicated. Streams that do not have BFE's determined have not been subject to detailed hydraulic study to determine potential flood extent, and water levels during the 100-year storm have not been determined.

The FIRM mapping of the 100-year floodplain is an essential resource that identifies the hazard of flood associated with areas in the region. There are a number of areas not depicted as floodplain which flood on a regular basis, pointing to the need for creation of more complete and accurate flood data. The extent of the 100-year flood plain imposes severe limitations on development and sound policy is to prohibit development throughout these mapped areas, as the Townships in the study area generally try to do.

Riparian Areas

The health of surface waters within the study area is relative to the health of the areas that surround them, commonly known as riparian areas. The term riparian is derived from the Latin "ripa", which means *bank* or *shore.*

Riparian areas are a diverse and important part of the ecosystem. Due to their position in the landscape, they are conveyed a great amount of energy and nutrients. At the same time, this position makes them most vulnerable, subject to a combination of effects which can be related directly to anthropogenic activities.

Riparian areas serve a multitude of functions for surface waters, the most critical of which is to provide a transition area from surrounding land uses. A forested riparian area acts as a stream or river stabilizer in many ways, controlling water temperature, stabilizing the stream bank, filtering pollutants from runoff, controlling sedimentation and contributing organic matter to the stream ecosystem. Riparian forests are among the most vigorous forest types, uniquely positioned to take advantage of abundant available water and receive the benefits of nutrient flow. They, in-turn, provide critical nutrients and woody debris which enhance stream health by providing habitat for in-stream organisms. This in turn enhances the overall health of the riparian ecosystem through ripple effects.

Careful delineation of riparian areas and implementation of appropriate management strategies can insure continued maintenance and potential enhancement of existing water quality. This is especially critical in more developed portions of the region, where water quality will continue to decline if riparian areas are not better protected. Figure 21 depicts riparian areas for the Sourland Mountain region, comprised of streams and a 150' foot buffer, wetlands and slopes greater than 15% which are adjacent and drain to stream corridors. A 150' buffer was utilized as it is the minimum buffer permitted by the NJDEP for Category One surface waters. Forested areas are depicted on Figure 21 to indicate where the potential exists to extend riparian protection into non-wetland areas. Protection of portions of these adjacent forested areas will only further enhance water quality and stream health.

Also depicted in Figure 21 are AMNET monitoring locations where impairment of benthic communities has increased since 1993 (refer to table on Page 41 for detailed data). The monitoring location along Pike Brook at County Route 533 now shows benthic communities in a severe state of impairment, with rapid decline experienced since 1993. While the other two monitoring locations, along Back Brook and Cruser Brook, showed decline, they can still be classified as moderately impaired. Looking at development patterns, it should come as no surprise that water quality is declining at these locations, given the amount of upstream development. The Pike Brook monitoring location is downstream of the other two, located just upstream of the confluence of Pike Brook with Bedens Brook. The pattern evident in the data would suggest a synergistic effect, with impairment increasing as you progress further downstream.

Development and subsequent loss of riparian areas can have a number of negative impacts on surface waters. First and foremost, loss of riparian areas eliminates filtration of sediment and nonpoint source pollution, greatly impacting waterways. In addition to sediment which enters the stream from off-site sources, deterioration and elimination of stream-side and stream bank vegetation lends to scouring, which causes bank deterioration and contributes to further erosion and sedimentation. Streams lacking forested or even vegetative riparian areas also lack habitat provided by woody debris. In-stream woody debris not only provides areas for fish and amphibians to reproduce, it also provides critical nutrients and substrate. Road crossings, which include bridges and culverts, are also destructive to riparian areas and stream channels. Crossings create breaks in an otherwise uninterrupted corridor, making wildlife migration difficult. Bridges are also prime sources of nonpoint pollution, often washed directly into the stream from the bridge deck.

New Jersey's recently adopted stormwater management regulations provide future guidance and additional protection measures for riparian areas. The "special resource protection" area requirement proposed to be implemented for Category 1 waters in the State would require a 300' buffer (minimum 150') around such streams. The special resource protection area is to be left in a natural state, with no installation of structural stormwater management facilities. The New Jersey Department of Environmental Protection is seeking to implement this requirement in order to protect surface water quality from new stormwater discharges, which often carry nonpoint source pollution and eroded sediment into waterways. The former regulations focused on moving stormwater runoff efficiently into surface waters. The newly adopted regulations will implement a vegetative buffer for Category 1 waters which will offer filtration of run-off, reducing nonpoint source pollutants and sediment reaching streams. As noted previously, a majority of the surface waters in the study area have been nominated by NJDEP for reclassification as Category 1 waters, which would be subject to the special resource area requirement.

In addition to the physical characteristics of riparian areas, there are intrinsic social and economic contributions which riparian areas make. Riparian areas provide passive recreation sites which can be enjoyed by the community. An interconnected stream network and its associated riparian areas present the opportunity for greenways which can span great distances.

Steep Slopes and Topography

The study area is characterized by two general landforms; gently sloping expanses in the lower elevations, and the higher elevation areas of the prominent Sourland Mountain ridge and plateau. Figure 22, which depicts the topography of the study area, was derived from a digital elevation model and “hillshaded” to add depth to the visualization. The Sourland Mountain ridge has its highest elevation around 567’.

The Sourland Mountain is best described as more of a hill or ridge than a mountain, a minor bump as you progress north through the state to the more dramatic topographic features of the New Jersey Highlands and the Ridge and Valley. The ridge or peak of the Sourland Mountain is more a flat plateau, a broad expanse of relatively homogenous composition that extends for more than 3 miles in places. Many of the areas where water courses flow off the mountain create dramatic topographic features, as is the case with Swan Creek, Rock Brook, Roaring Brook, Stony Brook and Moore Creek, where the erosive force of water has carved ravine-like elements into the landscape. There are also the less dramatic features of Baldpate Mountain, Pennington Mountain, Pheasant Ridge and the Princeton Ridge, which begins just south of Hopewell Borough and stretches southeast to Princeton Township.

Steep slopes, depicted on Figure 23, represent transitional areas in the landscape; transition from higher terrain to lower terrain and transition into areas of stream corridors. The latter are often created by the erosional effects of water scouring of the landscape. The most extensive areas of steep slope are found along the eastern face of the Sourland Mountain in Montgomery and Hillsborough Townships, around Baldpate Mountain, Pennington Mountain and Pheasant Hill in Hopewell Township and in limited areas on the north facing slope of the mountain. Aside from these areas, the remainder of steep slopes is located along stream corridors. The most dramatic surround Alexauken Creek, Moore Creek and Swan Creek.

Steep slopes have a number of implications for community development and the environment. Slopes in excess of 25% present serious limitations for development, often requiring extensive and costly engineering and construction. Development on slopes in excess of 15% can degrade the environment, if not properly managed. Since most slopes occur in and around the banks of streams and rivers, clearing in these areas creates the potential for erosion and stream sedimentation. With many of the steep slopes of the region occurring near the banks of rivers and streams, protection of steep slope areas becomes more critical. The clearing of trees and vegetation that stabilizes the slope not only causes erosion and sedimentation problems, it can also contribute to increased water temperatures in streams and rivers.

Another potential area of concern relates to agricultural operations near steep slopes and stream courses. Agricultural operations include the grazing of animals and use of pesticides and fertilizers. Where grazing occurs along steep stream banks, animals can seriously degrade and destabilize these banks when seeking water. Animals accessing streams through areas of steep banks can destroy vegetation while increasing erosion and sedimentation and introducing manure directly into surface waters.

Ridgelines

Ridgelines are valuable topographic features often prominent in the visual landscape. Simply defined, a ridgeline is *a horizontal line or demarcation representing the intersection of two slopes having generally opposing aspects, usually representing the highest common elevation of both.* The prominence of ridgelines varies depending on the surrounding terrain, and a ridgeline may not be visible from the surrounding landscape if there are only moderate elevation changes. Its visual impact is therefore diminished, as in much of the study area.

Figure 24 depicts the ridgelines in the study area, delineated based on the above definition. Utilizing the NJDEP's 10 meter digital elevation model, contour information and three-dimensional visualizations of terrain, ridgelines were delineated manually. The most prominent ridgelines in the region are associated with the Sourland Mountain ridge, Baldpate Mountain, Pennington Mountain and Pheasant Hill. The majority of ridgelines in the study area run parallel to each other. There are a number of other minor ridgelines throughout the study area, as depicted on Figure 24.

Development of ridgelines can have major impacts on visual resources as many times, forested ridgelines are cleared to make way for homes.. From an individual perspective they represent desirable locations for residential home sites, taking advantage of views to the surrounding landscape. From a community perspective, ridgelines are desirable places to protect. Selective cutting of trees and careful placement of the building envelope can minimize disturbance to the visual landscape. Ridgelines should be considered valuable community assets;development on ridgelines replaces these community assets to the benefit of few.

Animals, Plants and Habitats of the Sourland Region

New Jersey is endowed with a remarkable wealth of biological diversity. Its coastal location in temperate latitude, its diverse topographical elements with their unique ecological attributes and its position along a major bird migration corridor provide for an abundant array of plant and animal species. The Sourland Mountain region hosts an ample share of this rich natural heritage. Its extensive forest and rural landscape provide the greatest block of intact habitat in the state's Piedmont province, which stretches diagonally across the middle of the state at the interface of northern and southern ecosystem types.

Protective stewardship of New Jersey's cherished natural heritage presents extraordinary challenges. Habitat—the place where a species finds shelter, sustenance and a place to reproduce and perpetuate its kind—continues to be lost to development despite aggressive public and private efforts to preserve it. Over the last few decades, there has been an astonishingly rapid consumption of habitat in central New Jersey; Land Use/Land Cover maps spanning nearly thirty years reveal that the integrity of habitat in the Sourlands region is in jeopardy.

This section provides an overview of the habitats of the Sourlands and how the requirements of animals and plants that occupy the region are met by those diverse habitats. Review of the available biological data and of pertinent scientific literature highlights a number of attributes that make the Sourland Mountain Region biologically unique and precious.

- The Sourland Mountain region is one of only three major areas of unbroken habitat in New Jersey and is a critical location mid-way between the Highlands and the Pinelands.
- The Sourland Mountain region contains a variety of habitat types of high quality and of substantial size, ranging from grassland to mature woodland and including a continuum of successional stages which support a rich diversity of biotic communities. The Nature Conservancy identified 7,737 acres of core forest within their 28,860-acre Sourland Mountain Matrix Block; the New Jersey Landscape Project identifies 24,582.14 acres of critical habitat.
- The Sourland Mountain region includes the largest contiguous forest in central New Jersey.
- Nearby land use patterns, combined with the size, shape and composition of the forest contribute to the high quality of Sourlands woodland habitat, especially for forest interior nesting birds.
- The Sourland Mountain region is a critical stopover point for migrating birds using the Atlantic Flyway and is one of New Jersey's top fall migration stopover sites. Protection of high-quality stopover sites is as necessary for long-distance migrants as their breeding and over-wintering habitats.
- The Sourland Mountain region supports a great diversity of bird species, many of which are listed as either threatened or endangered, or are being tracked as species of special concern.
- Vernal pools—isolated wetland depressions that are seasonally filled with water—are common in parts of the Sourlands. Some of these are known breeding sites for a number of herptiles who require these pools for egg laying and early life stages.
- The Sourland Mountain region may be the last refuge of some of the complex plant communities that once flourished in central New Jersey. Sixteen plant species that are either endangered or of special concern in New Jersey have been documented in the Sourlands to date.

The Sourland Mountain region is an ecological island in central New Jersey. Nowhere else in the state's rapidly developing mid-section can one find such a vast swath of unbroken habitat. Unique geological and hydrological features of the Sourlands have presented challenges to human encroachment and opportunities for animals and plants. The forest that covers the ridge and slopes has been largely untouched for many years. Past and present agricultural activity on the more hospitable lower flanks and foothills has created a continuum of habitat types ranging from grasslands and meadows, to shrub-scrub or old fields, to early successional woodland. Freely flowing water courses originating on the mountain and its foothills provide riparian and aquatic habitat. The perched water table supplies an ephemeral yet critical habitat for a number of specialized organisms. This suite of habitat types combine with the geology and contours of the land, its soils and hydrology and even with the aspect of the ridge to create an environment uniquely suited to sustain an incredibly diverse array of plants and animals. Loss of or impact to any of these resources will have a direct effect on many of these species and the overall biodiversity of the area. Although anthropogenic, or manmade, activities have the most impact, natural forces can prolong and often enhance the effect that humans initiate through development.

The very traits that render the Sourlands an island of biodiversity also make the area a desirable, if challenging, place for human habitation. The forested slopes and bucolic valleys are tempting to those who seek a rural setting for a new home. It is not unusual to see real estate ads with statements such as, "…nestled in the Sourland Mountains." Residential development, egged on by commercial development along the Route 1 and I-95 corridors, is pressing in and already threatens the lower flanks of Sourland Mountain itself. Long held at bay by lack of public utilities, scarce groundwater, and soil percolation too poor to support septic systems, newer technology and importation of drinking water can open the doors for development of what had been a virtually pristine environment.

But to the exhausted migrating bird nearing the end of a 3,000-mile journey from South America, the Sourlands are not just a coveted piece of real estate. To one who has just traversed a good part of the northeast corridor, with its cities, industrial and commercial parks, and endless suburban tracts and who has perhaps touched down briefly in the Pinelands, the Sourlands are a critical oasis in an impervious desert. To a scarlet tanager, for instance, this may be its destination—a suitable place to call for its mate and make a home. To a bay-breasted warbler, it is a refueling stopover, where it feeds on the tiny caterpillars that emerge on the oaks and tulip poplars to build up fat stores for a few days before continuing its long northward flight.

The Sourland Mountain region is a reservoir of biodiversity. Not only does it provide prime habitat and a critical migration stopover site but, because it supports larger populations of many organisms, it can serve as a source of genetic diversity for other populations of the same species that utilize smaller habitat patches nearby.

Appendices 4 through 7 contain lists of birds, mammals, reptiles and amphibians, insects and plants assembled in the course of several biological surveys. The existing species lists are not a complete inventory of the flora and fauna of the Sourlands but, rather, are representative of the abundance and diversity of the biota of the region. In addition to the species whose presence has been documented, The Nature Conservancy has identified numerous species that could be expected to be present in the region based on the extent and quality of habitat. Data on the ecological importance of the Sourland region will continue to become available as more scientists and volunteer naturalists focus their attention on identifying the resource factors that make the area unique.

Habitat Diversity and Quality in the Sourlands

At the time of first human settlement, the vegetation covering the Sourland region was most likely a fairly homogeneous deciduous forest. Native Americans in the area practiced limited agriculture and field rotation, creating openings in the vast forest canopy which invited some non-forest dwelling creatures to occupy the land and eventually led to some isolated patches of successional growth as fields were abandoned. Beginning in the mid- 17th century, European settlers and their descendants brought with them more intensive agriculture, including opening up large segments of the forest in the valleys and on the lower flanks of the mountain for villages, pastureland and row crops. Trees were harvested from woodlots on the higher elevations. In time, the face of agriculture in the region changed and fields were abandoned, either because of changing demographics or because the type of farming eventually proved unsuited to the region. Over the course of several decades, fallow fields underwent a series of predictable and relatively rapid changes in the composition of their vegetation, a process known as ecological succession. Meanwhile, new areas were cleared to make way for new farms. Such land use changes that have occurred irregularly over the past hundred years or so have led to the current patchwork of habitats in various stages of succession, ranging from active farmland to nearly-mature woodland, mostly along the lower flanks and in the foothills. The mature forest that now covers the ridge is secondary growth that replaced the virgin old-growth forest that was logged many years ago. This pattern gives an historical record of the use and disuse of the fields and provides a wide range of habitat types that support a remarkable diversity of animals and plants.

Land use/land cover mapping clearly shows the extent of the Sourlands forest, the most dramatic feature of the region; it also reveals how development intruded upon this habitat block between 1972 and 1995. The effects of human activity are not always immediately evident from the air or the ground. To the layperson, it may appear that a small opening in the forest canopy to accommodate a house would have little effect on the large contiguous forest, as there is so much of it covering the area. The area disturbed might not even create a gap in the canopy. But each time the forest is disturbed, even in small patches, the impact can stretch for up to 1,000 feet in all directions (Flaspohler, Temple and Rosenfield, 1999.) The hotspots created by clearing result in the edge effect, where the integrity of habitat is diminished in a gradient. Even though relatively large lots are required as a minimum in the region, the separation they create between dwellings does not mitigate the effects of forest clearing and removal of the understory. And the fact is that many of the species that live in or make use of the Sourland region rely on both the quantity and the quality of the forest and understory; as it becomes degraded and disappears, so will these species.

The Nature Conservancy (TNC) identified 7,737 acres of core acreage in their 28,860-acre Sourland Mountain Matrix Block, the region east of Route 31 and north of Route 518. TNC included as core forest only that acreage not fragmented by any break in the forest canopy equal to or greater than 10 meters in width. Linear corridors, including roads, utility rights-of-way and hiking trails are major contributors to fragmentation effects in forest matrix blocks. Disturbances include habitat edge effects, pollution, collisions, visual stimuli and noise and vary depending on the type of corridor. Based on extensive review of scientific literature, TNC has assigned buffer width values ranging from 0 to 500 meters, depending on the degree of disturbance generated. Primary roads are considered to influence forest habitat to a depth of 500 meters, local roads 100 meters. Hiking trails less than 10 meters wide are not considered a canopy break of sufficient width to have a negative impact. The buffers are not included in the core forest acreage. What remains is considered forest habitat that is capable of supporting the complete suite of forest interior species appropriate for the region. Along with other forest patches that are not included as core forest, the Sourland Mountain Matrix Block also contains significant grasslands in the form of hay pasture, covering 27% of the matrix block. Only 5% of the matrix block is developed cover. TNC also identified 55 total stream miles in the block. These estimates do not include the parts of the Sourland Mountain region west of Route 31; nor do they include Alexauken Creek, which was designated a Category 1 stream in July of 2004. The New Jersey Landscape Project identifies 24,582 acres in the Sourlands either as known habitat of species that are either endangered, threatened or of special concern, or as suitable habitat for such species.

Sourlands Birds

Among the many animals in the Sourland region, of particular interest is the richness of bird species, both resident and migrant, for whom the complex of grasslands, old fields, shrublands and mature forest offer an exceptional opportunity to either make their home or refuel for continued migration. This incredible avian diversity can be directly linked to the broad spectrum of high quality habitats. One study undertaken in the region supports the theory that the wide range of habitats and their juxtaposition is what makes the Sourland region unique in its ability to support a rich variety of both resident and migrant birds (Suthers, 1988.) While conducting a long term study of the succession of old hayfields adjacent to a variety of wooded areas (wet woods, early successional and climax woods), Suthers found that as succession progresses in fields abandoned at different points in time, habitat becomes more diverse, supporting a greater variety of birds. Altogether in this particular study, 51 species of stopover migrants and 70 species of resident and breeding birds were noted.

Bird Migration in the Sourlands

Birds can be classified as either permanent residents or migrants, with short-distance migrants wintering in the continental United States and long-distance migrants wintering in Central and South America. This classification can further be broken down into passage migrants and locally breeding species. Passage migrants are those whose breeding grounds are in the northern tier of states or Canada. Most migratory birds arrive in central New Jersey between mid-April and late May, with the peak occurring around the second week in May. The mixed oak forests of the Sourlands are a favorite stopover for passage migrants such as Cape May warbler and Blackburnian warbler, who will stay only briefly to gorge themselves on the caterpillars that favor this type of woodland. Many of the breeding migrants, such as wood thrush and red-eyed vireo settle in at the same time. The Neotropical, or long-distance, migrants are the group most severely affected in recent decades by human manipulation of the environment. As development has continued and habitat has been converted to other land uses in both the United States and Central and South America, the numbers of long-distance migrants has severely declined locally (Floyd, 1990) and regionally (Terborgh, 1989.)

New Jersey Audubon Society in *New Jersey at the Crossroads of Migration* identifies the Sourlands as one of the key portions of New Jersey that have been designated Migratory Bird

Corridors. The Sourland Mountain is located on the New Jersey Piedmont physiographic region, which presents a smooth transition between the relatively low and flat coastal plain and the highest elevations and ridges of the New Jersey Highlands. It is situated midway between the Pinelands and the Highlands and provides a critical stopover point for migrating species using the Atlantic Flyway, which generally extends from the western coast of Greenland south along the eastern coast of Canada and the United States. Studies undertaken by the New Jersey Audubon Society in fall of 2001 using NEXRAD Radar showed that the Sourland region had a frequency of stopover use between 21 and 26 days, the highest range possible. No other area outside the Pinelands exhibited so high a frequency. And, although the bird density for the entire season was not as great as in the Pinelands, the frequency of stopover use was as great (New Jersey Audubon, 2001.) New Jersey Audubon identifies the fact that suitability of an area for use as a stopover site is solely related to the quality of available habitat that is present. Stopover migrants require a place that provides shelter and fuel. If those requirements are not met, then the utility of an area diminishes. A study published by Suthers, Bickal and Rodewald in June 2000 shows that use of particular habitat types, in this case open shrubland during fall migration, depended largely on the availability of fruit. As high quality fruit supplies begin to diminish, so does the appearance of certain species of birds.

In their Issue Paper, "Protecting Stopover Sites for Forest-Dwelling Migratory Landbirds," The Nature Conservancy states that ideal migration stopover sites "provide fresh water, protection from predation, and food resources acquired easily enough that birds can survive and regain mass lost through catabolism during their travels." They go on to list criteria for defining important stopover sites, including relative abundance of all or a subset of migrants; resource-rich sites where birds regain lost energy; and, spatial relationship to other sites (The Nature Conservancy, 2001.) Available species data shows that the Sourlands region meets these criteria. Maintaining the quantity and quality of habitat types is critical to continued use of the Sourland region as a stopover point for migratory birds, both spring and fall. New Jersey Audubon Society's *New Jersey at the Crossroads of Migration* states, "Protect all of the breeding woodland in North America and all of the rain forest in Central and South America and tanagers will still decline *unless the habitat they need during migration is also preserved."*

Breeding Birds of the Sourlands and Their Habitats

Birds can also be grouped based on the habitat type they require for breeding. Some are grassland specialists; others nest only in deep woodlands. Still others prefer the early successional stage known as shrub-scrub or savannah-like habitat while some build their nests in edge habitat—the margin where woodland meets a farm field, park, lawn or other non-forested opening. Even within habitat types some species need or prefer a certain minimum patch size. Land use adjacent to a habitat patch will also influence its suitability for usage by some sensitive species. While some bird species may be tolerant of human disturbance, or even thrive in its presence, most suffer negative impacts on breeding success because of it. The house wren is a familiar species that will readily build a nest and successfully raise a brood in a nest box at the edge of a patio and American robins flourish in landscaped suburban neighborhoods. But by and large, birds do not adapt well to perturbations in the environment and are rather rigid in their habitat requirements. They are genetically and behaviorally programmed to build their nests of the same materials in the same type of habitat at the same level relative to the ground as they have done over thousands of generations. There is even a tendency for offspring to return to their ancestral homes to seek out a territory when it is their turn to breed.

Habitat fragmentation is the condition that results when a once-contiguous habitat is disrupted and broken up into smaller remnants of different sizes and shapes interrupted by altered landscape. Birds are affected in all life stages by fragmentation. There has been considerable research into the reasons why the size of a habitat patch is critical to the breeding success of a species. Overall, Neotropical migratory birds seem to be most sensitive to habitat fragmentation. One reason seems to be that most of these species have only one brood per season, unlike short-distance migrants such as American robins who may have as many as three broods (Faaborg, 2002.) There also is a relationship between migration distance and mortality during the journey, especially for young birds on their first trip. Intra-species competition can be a factor; a breeding pair simply will not tolerate another of the same species in proximity to its own nesting territory. This territory varies widely among species. Inter-species competition, on the other hand, does not seem to be a consideration. Availability of preferred foods could be another determinant. But vulnerability of the eggs, nestlings and brooding parents to predators is probably the most important factor. Most long-distance migrants build open nests, while many short-distance migrants and permanent residents such as Eastern bluebirds nest in cavities. An open, cup type nest built on the ground by a black and white warbler carries more predation risk than a Baltimore oriole's pendulous nest hanging from the tip of a branch 20 feet from the ground at the edge of a small woodland. A house wren's nest in a tree cavity or nest box is safer still, thus their tolerance of activity on the patio.

The variety of habitat patches of substantial size within the Sourlands region supports a robust complex of avian populations. Most of the species that historically have bred in central New Jersey still breed successfully in the Sourlands even though they may have disappeared from other parts of the area. Among the 10 species with 30% or more of their statewide breeding range in the Piedmont, five are noted in the surveys referenced in this report: black-capped chickadee, bobolink, ring-necked pheasant (non-native species), rose-breasted grosbeak and warbling vireo. These are included among results of the New Jersey Breeding Bird Atlas published by New Jersey Audubon in their landmark book, *Birds of New Jersey*, which documents the distribution of all of the state's breeding birds.

Mature Forest

Among its many habitat types, the largely intact mature deciduous forest that resides in the Sourlands is arguably its most unique ecological treasure. The nearly 12,000 acres of predominantly mixed oak forest on Sourland Mountain and the large forest blocks west of Route 31 comprise the largest remaining contiguous woodlands in central New Jersey, the most significant remnant of the vast forest that once covered the state's Piedmont region. Other forest patches of sufficient size to support populations of interior woodland species are found to the west of Route 31 and on Baldpate Mountain. The primeval stands of trees were harvested long ago and some managed woodlots remain. But widespread timber harvest ceased well over a hundred years ago and the forest is at or near climax, the stage at which composition of the forest changes at a very slow rate compared to the earlier successional stages. Using a tree diameter calculation method, Dr. Henry Horn of Princeton University estimated that some trees in what he refers to as a "majestic tulip woods" on Baldpate Mountain are up to 120 years of age. Many ash, oak, hickory and beech trees were estimated to be from 60 to 75 years of age (Dr. Henry S. Horn, personal communication, 1990.) His method involved extrapolation based on a Princeton University B.A. thesis that plotted diameter versus growth rings of cored or previously sawn trees in the Sourland Mountain Preserve. That study tabulated some beech and tulip trees well over 150 years of age and several white oaks 200 or more years old (P.G. Newman, 1987.)

Despite a vigorous deer population in the area, itself a consequence of human impacts, a healthy understory of native shrubs and saplings is flourishing in many parts of the forest, accompanied by a varied herbaceous layer. This complex woodland structure is vital for many bird species, whether for breeding, migration stopover, or over-wintering. Browsing white-tailed deer can decimate this layer where they are numerous, but their populations tend to be less dense in deep woods than along edges.

It is the size, shape, composition and adjacent land use that make the relatively unfragmented forest of the Sourlands a haven for so many woodland birds. It is not just the acreage of a patch that makes it suitable habitat, but also its shape. A long and thin woodland may provide a wildlife corridor, but the entire piece may be exposed to edge effects, whereas the same acreage in a somewhat circular shape would contain an interior core free from those effects (Faaborg, 2002.) A comparative study of two forest patches, the Institute Woods in Princeton Township consisting of 155 hectares (383 acres) and Baldpate Mountain in Hopewell Township, consisting of 509 hectares (1,258 acres) showed that the larger of the properties supported a greater density of forest interior breeding birds. Using a transect census method, the study documented 198 pairs of forest interior breeding birds per 100 hectares on Baldpate versus 51 in the Institute Woods (Floyd, 1990.) In addition to the size of the habitat, there is good evidence that the landscape within which a forest patch is located affects the intensity of edge effects. Predation pressure varies according to the predators supported by the matrix surrounding the forest (Faaborg, 2002.)

Forest fragmentation due to development produces obstacles to breeding birds, particularly those that rely on interior forest habitat for breeding. As fragmentation occurs, more edge is created relative to forest interior. As the core becomes smaller, certain sensitive species will tend to cluster their territories in the area farthest from the edge. Patch size is critical for a number of species of forest interior nesting birds, which have been severely impacted in their breeding grounds by loss of forest mass and the ever-increasing creation of edge due to expanding development. But studies show that it is not forest size and edge, *per se*, that are causing the decline of these birds but rather factors associated with edge. In his book, *Where Have All the Birds Gone*, Dr. John Terborgh cites the Princeton University Ph.D. thesis work of David Wilcove. As part of this work, Dr. Wilcove found that forest interior birds bred right up to the edge of a large reservoir surrounded by forest. This research seems to imply that certain properties of edge, such as what is on the other side of the forest-field interface, are impacting the birds. A clue lies in the fact that many of these birds lay their eggs in open cup nests on or near the ground, making them vulnerable to predation. Cavity nesters and those who build their nests in high branches are less vulnerable to predation than ground nesters. Wilcove found that the most common nest predators are raccoon, opossum, striped skunk, dog, cat and blue jay. All of these are animals associated with human habitation and are more likely to prowl a forest edge than penetrate into the interior. Development has resulted in increased breeding success and population sizes of the predators that far exceed those found in pristine areas. In looking at forest patches of various sizes in several different settings, Wilcove found that nest predation rates in small suburban woodlots neared 100 percent as opposed to just 2 percent in a large national park. Predation rates were intermediate between these two patch size extremes.

Nest parasitism is another serious obstacle to breeding success created when forests are fragmented and edge is increased. Cowbirds, a known nest parasite common only in the Great Plains when the American colonies were first settled, are dramatically increasing in numbers in the east as the extent of edge habitat increases. Their frequency is greatly diminished in the forest interior as they rely primarily on short grass pastures for feeding and have a confined range (Faaborg, 2002.) These birds lay their eggs in the nests of other species, often smaller than themselves, who are then burdened with the task of raising these larger cowbird nestlings at the expense of their own. Some Neotropical species are being driven to near survival threshold levels by cowbird parasitism. It is thought that they used the nests of about 50 species before European settlement; they now use around 200, many of which lack an evolutionary tendency to recognize and remove the alien eggs from their nests (Terborgh 1989.) Studies referenced by Terborgh provide alarming statistics; one study found 37 cowbird eggs in 11 wood thrush nests and only 12 wood thrush eggs. 29 of 30 wood thrush nests had been parasitized.

Edge is suitable, even preferred habitat for birds that nest in trees but forage in fields, such as brown thrashers and eastern towhees. And the fact that birds are easier to spot at the edge of a woodland as they fly back and forth gathering food for their young may give the impression that bird life there is abundant. But the important fact is that certain species, because of the type of nest they build and its location, are losing ground as forests shrink in size and predators and parasitic birds gain access. It is important to note that edge effects that result from development are particularly harmful, as they usually cannot be reversed; edge effects from logging activities can be reversed and even avoided with appropriate management.

The forest patches on Sourland Mountain and Baldpate Mountain are of sufficient size and appropriate dimensions to minimize edge impacts on interior nesting Neotropical migratory birds. A 2004 study conducted on Baldpate as part of the Birds in Forested Landscapes Project of the Cornell Lab of Ornithology is reassuring. Data collected at two survey points within the core of the 1200+-acre forest in late May and early June noted no cowbirds were seen or heard. This same study did reveal the presence of several forest interior species, including hooded warbler, Kentucky warbler, Canada warbler, veery, wood thrush and yellow-billed cuckoo. This study employed a different method (point count) from Floyd's 1990 breeding bird census (transect method) so direct comparison of numbers of pairs cannot be made. However, this data and other observations indicate that the Baldpate forest still hosts the same forest interior specialists as it did 14 years before.

<u>Grasslands</u>

Typically, grasslands in New Jersey other than marshes are agricultural fields, either maintained as pasture or mowed regularly for hay. There is some debate as to when grassland birds first occupied New Jersey and other eastern states that were mostly covered with a vast, contiguous forest before European settlement. Much of the state was, indeed, a savannah-like landscape in the immediate post-glacial (late Pleistocene) period. Fossilized skeletons of grassland birds from 14,000 to 20,000 years ago have been found (NJ Audubon Grassland Habitat Symposium, 2004.) It is likely that, as the forest filled in, grassland pockets were intermittently established by lightning initiated fires, the activity of beavers or severe flood events, leaving isolated relict populations of grassland birds. More pockets were created when Native Americans who first occupied the land cleared patches for small-scale agriculture.

In modern times, the woodlands of the lower flanks and foothills of the Sourlands region were cleared when the area was settled and farming was widespread. Grassland bird species readily took advantage of the fields, particularly those where warm season native grasses were flourishing. In time, these native grasses were replaced by the European species such as timothy, bluegrass and tall fescue, which were considered more productive in spite of the fact that they are less drought resistant and require more nutrients than the native clumping grasses such as bluestem, Indian grass and switch grass. These imported cool season grasses call for an early summer mowing regimen, which has proven detrimental to many grassland species. Habitat conservation must compete with a market preference for cool season grasses for feeding horses and livestock.

The grasslands that flank the Sourland ridge in the Amwell and Hopewell Valleys provide critical habitat to a number of bird species. Some of these species require an expansive viewspace—considerable distance from the forest edge and a low horizon—for nesting, which aids reproductive success by reducing the threat of predators that lurk at the edge (Mattice, 2004.) It is noteworthy that, in New Jersey, grassland species as a group are the most severely threatened birds when considered by habitat preference. More of our state's threatened and endangered bird species are grassland habitat specialists than any other habitat group—41% in all. Species surveys and anecdotal reports list bobolink, meadowlark, upland sandpiper, grasshopper sparrow and American kestrel among those seen in the Sourlands. These birds are declining because the meadows and hayfields they have used for nesting for generations are also prime land for housing subdivisions and corporate parks. Grasslands are being swallowed up at an incredible rate. Fortunately, hay and livestock farming continue to prosper in the Sourland region and some farms of sufficient size to support these sensitive species remain. Fields of at least 100 acres are best for maintaining populations of grassland birds. A large field may support several breeding pairs, averaging 10 acres per pair. However, a 10 or 20-acre field will support none (Maryland Partners in Flight, 1999.) At the same time, these farms present a habitat management challenge that will require education and economic incentive if the fields are to provide optimum breeding habitat. The preferred cool-season grasses typically are mowed in June. For the sake of birds that nest in the grasslands, it should not be cut before mid-July. For birds that raise a second brood, such as Eastern meadowlark, only a first mowing after mid-August would spare the second clutch of young. Several federal and state funding incentives are available for habitat preservation and enhancement for grassland species.

<u>Other Habitats in the Sourlands</u>

When cultivated fields are abandoned, secondary succession begins. Initially, forbs or flowering herbaceous plants will colonize a fallow field, providing nectar and pollen for butterflies and other insects. These creatures, in turn, provide food for some species of birds. In fall and winter, the seeds of the flowering plants provide food for southward-bound migrants and over-wintering birds. Prime examples of such fields were found at Alexauken Creek Wildlife Management Area.

Randomly scattered shrubs and young trees take hold in suitable microhabitats throughout a field that has been fallow for three years or more. In the Sourlands, among the first of these pioneers would be Eastern red cedar which provides choice shelter for nesting birds that breed in shrub-scrub habitat, as well as food for over-wintering birds. In time, other shrubs and vines join them to form small thickets. This is the favored habitat of bird species such as yellow warbler, field sparrow and American goldfinch.

Native hardwoods begin to shade and crowd out the earliest volunteers in a long-abandoned field. Trees typically are just a few inches in diameter and closely packed together. The last remnants of the earlier successional stage, including Eastern red cedar, panicled dogwood and gray birch may continue to survive. This stage has been thoroughly studied by Hannah Suthers at the Featherbed Lane Bird Banding Station and her data on birds in this and earlier successional stages are listed in Appendix 4.

Birds in Peril

The Sourlands region is providing essential habitat for a great diversity of bird species as shown in Appendix 4. Many of these are species who are listed as either threatened or endangered, or are being tracked because their numbers are on a steep downward trajectory. The avifauna consist of more species than any other vertebrate class. These species are incredibly diverse in their food and habitat requirements and most are very sensitive to environmental perturbations. What makes the Sourlands region so critical to avian diversity and abundance is that it consists of a variety of habitats of impressive size that, for various reasons, are relatively untrammeled by human disturbance. From the aerial perspective of a bird in flight, it is a welcome refuge and a place to call home.

Data collected so far indicates that a number of bird species in crisis are finding safe harbor in the Sourlands. Bird populations have been tracked for a number of years by federal and state agencies and conservation organizations. In New Jersey, the New Jersey Endangered and Nongame Species Program maintains listings of species of special concern. In addition to data collected by state biologists, documentation by skilled volunteer naturalists provides important tracking information. The New Jersey Natural Heritage Program database is a vital repository of information on sightings of threatened and endangered species. The New Jersey Breeding Bird Atlas research was conducted from 1993 through 1997 and published by New Jersey Audubon Society in the book *Birds of New Jersey* in 1999. Surveys were conducted on specific sites by volunteer organizations in the Sourlands in 1990, 1994 and 2003. Some parts of the Sourlands are included in annual Christmas Bird Counts. One citizen scientist has been compiling her own lists of breeding birds on Baldpate Mountain and in 2004 did so as part of the Cornell Lab of Ornithology's "Birds in Forested Landscapes" project. And birders often make note of special sightings that are not part of a particular project—anecdotal notations that round out the body of knowledge on birds of the Sourlands.

Currently available lists of birds found in the Sourlands indicate the region provides shelter and refuge to many bird species in peril, identified in three separate sources.

New Jersey Endangered and Nongame Species Program

According to New Jersey Endangered and Nongame Species Program status definitions, "Endangered" applies to a species whose prospects for survival within the state are in immediate danger. "Threatened" applies to species that may become Endangered if conditions surrounding it begin to or continue to deteriorate. "Special Concern" applies to species that warrant special attention because of some evidence of decline, inherent vulnerability to environmental deterioration, or habitat modification that would result in their becoming Threatened.

Table 10 - NJ Endangered and Nongame Species Program – Special Concern Species Listing Documented in the Sourlands

Endangered	Special Concern
Upland sandpiper	Northern harrier
	Sharp-shinned hawk
Threatened	American kestrel
	Winter wren
Red-shouldered hawk	Veery
Cooper's hawk	Gray-cheeked thrush
Barred owl	Kentucky warbler
Grasshopper sparrow	Canada warbler
Bobolink	Yellow-breasted chat
	Eastern meadowlark

WatchList

This list calls attention to birds at conservation risk before they require federal listing and stresses preventive action over last-ditch intervention. The WatchList is based on the Partners in Flight conservation priority scoring system designed to conserve viable populations of birds and the biological systems on which they depend. Partners in Flight is a cooperative effort involving partnerships of many federal, state and local agencies, philanthropic foundations, professional organizations, conservation groups, the academic community and private individuals.

Table 11 - WatchList Birds Documented as Breeding in the Sourlands

American woodcock Willow flycatcher Wood thrush Blue-winged warbler Prairie warbler Worm-eating warbler Kentucky warbler Canada warbler
In addition, two other WatchList species, Bicknell's thrush and prothonotary warbler, have been documented as migrants in the Sourlands region.

<u>Partners in Flight Physiographic Areas Plans – Mid-Atlantic Piedmont</u>

This plan lists species by habitat type within each physiographic region and assigns scores to the species, lists population trends and recommends action levels. The following are species documented in the Sourlands listed in the Mid-Atlantic Piedmont Area Plan's Priority Habitats and Suites of Species.

Table 12 – Partners in Flight Mid-Atlantic Piedmont Area Plan

Priority Habitats and Suites of Species -Species Documented in the Sourland Region

<u>Deciduous Forest</u>	<u>Agricultural Grassland</u>
Wood thrush Kentucky warbler Eastern screech owl Chimney swift Prothonotary warbler Acadian flycatcher Scarlet tanager Louisiana waterthrush Canada warbler Worm-eating warbler	Upland sandpiper <u>Freshwater Wetland</u> Green heron
<u>Shrub - Early Successional</u>	
American woodcock Prairie warbler Northern bobwhite Field sparrow Eastern towhee Blue-winged warbler Willow flycatcher	

The Executive Summary of the Mid-Atlantic Piedmont Plan states, "The future of wildlife habitat depends on protection of patches of conservation significance and the manner in which inevitable continuing growth alters the environment. Forest habitat remains relatively abundant, but is very heavily fragmented. Identification and maintenance of those blocks large enough to support the full array of breeding birds should be a priority." The species lists indicate that Sourland Mountain fits the definition of a priority habitat site.

Reptiles and Amphibians

The region also supports diverse populations of amphibians and reptiles (see Appendix 5.) Critical to the continued success of amphibian populations in particular are vernal pools. Vernal pools are "confined wetland depressions, either natural or man-made, that hold water for at least two consecutive months out of the year, and are devoid of breeding fish populations." (Tesauro, 2003) Many amphibian species, frogs and salamanders in particular, are obligate to early spring pools for breeding (see Appendix 5.) One study of a vernal pool in the Sourland region revealed that no less than 500 spotted salamanders and 700 wood frogs visited one pond to breed (Heilferty.) Currently, only certified vernal ponds receive protection under the State wetland regulations. Many of the pools that are certified are on lands that are already protected from development. The Heilferty study found that individuals had come from as far as 600 yards from the pool under observation; as such, the maximum wetland buffer of 150 feet for exceptional resource value wetlands would do little to protect the critical area surrounding a vernal pool. Currently, NJDEP and Rutgers University are providing training for individuals who wish to survey and certify vernal pools. As pools are certified, they are documented in an internet mapping application and afforded protection. An inherent problem lies in documenting pools that are not on public land.

The rocky terrain of Sourland Mountain and Baldpate Mountain offers excellent habitat for some snakes. Rock outcrops and rock piles are perfect for basking snakes. Residents, including a Somerset County naturalist, have reported sightings of Northern copperhead snakes on both Sourland and Baldpate Mountains and the species had been noted in the past at what is now Alexauken Creek Watershed Management Area. This species was sought for but not seen in the course of the two Washington Crossing Audubon biological surveys, nor in the Baldpate Mountain survey. A variety of other snake species were documented. Several turtle species appear in the survey lists as well.

Mammals

The region is also home to a host of animals representing a number of mammalian families and habitat preferences (see Appendix 6 and lists included in the biological surveys.) In addition to these lists, there is the occasional anecdotal report of a black bear, bobcat and Eastern coyote.

Insects

A thriving, diverse insect population can be an indicator of a healthy environment. They fulfill a vital role in maintaining biological communities by serving as pollinators for many plant species and as a food source for many birds, reptiles and amphibians and small mammals. Except for butterflies and dragonflies, there was no concerted effort to identify insects in the biological surveys but incidental sightings were noted. Nevertheless, the species lists represent a broad range of insect families.

Plants

The Sourlands region supports diverse plant communities including wet and dry meadows, old fields in succession, young second growth forest, riparian and wetland forests and older second growth forest (McCormick and Peifer, 1990.) The forest that covers the Diabase ridges of Sourland and Baldpate Mountains is the mixed oak type (Collins and Anderson, 1994.) White, red, black, scarlet and chestnut oaks dominate this type of forest but, in the areas surveyed, shagbark, bitternut and pignut hickory, tulip poplar and American beech are very well represented, creating a spectacular mixed hardwood forest. Flowering dogwood, sassafras, ironwood and other small trees fill the understory layer and native vines such as Virginia creeper, grape and poison ivy are abundant in some locations. Native shrubs such as several species of virburnum and dogwood thrive in areas that have not been over-browsed by deer. Many of these trees, shrubs and vines are important food sources for southward migrating birds in the fall and for over-wintering birds (Suthers, Bickal and Rodewald, 2000.)

New Jersey is botanically very interesting. The historic composition of its flora contains species characteristic of both southeastern and northeastern states. This is especially true of the Piedmont, where many southern species reach their northern climatic limit and some northern species reach their southern limit. Central New Jersey is also a region where a growth explosion has obliterated much of the natural botanical habitat. The Sourlands region may be the last refuge of some of the complex plant communities that once flourished here. One indication of the integrity of habitat in the Sourlands is the number of species listed by the State of New Jersey as threatened or endangered that have been documented there (see below.) The sheer number and range of plant species overall attests to the diversity of habitat types. The fact that the bulk of these are native species that have not been overwhelmed by invasive alien plants may be attributable to the size of the habitat patches and lack of intense development in the region.

It is worth noting that many invasive species are landscape plants that have jumped the interface between homestead and natural lands. Invasive and exotic species continue to be a problem associated with clearing of the forest. As holes open in the canopy, the increased amount of sunlight reaching the forest floor aids perpetuation of opportunistic non-native plants. Many invasive species begin as prized ornamentals used in landscaping around new homes and include a host of trees, shrubs, groundcovers and herbaceous perennials (see Appendix 3.) Most of these species have little or no value to native wildlife and compete with native plants for habitat. Many of our rarest wildflowers are fragile woodland species that can be overwhelmed by aggressive alien plants such as garlic mustard, stiltgrass and barberry. While invasive species are problematic when the forest canopy is thinned, they are more of a problem when trees are clear cut, as it takes decades for the canopy to close enough to provide the shade that eliminates problem vegetation. Even careful logging activity aids invasive species; selective cutting can still thin the canopy enough to change light conditions and make the environment favorable for their growth. The rapacious mile-a-minute vine and Asiatic bittersweet retard early successional growth and even native wild grapes that flourish in forest openings can inhibit closing of the canopy. And while deer are effective at eliminating desirable native vegetation in the understory of the forest, they tend to avoid many of the invasive plants. Invasive plants such as Canada thistle and multiflora rose present a challenge in grassland habitats.

New Jersey is rapidly losing its rich botanical heritage to development, inappropriate management or misuse of preserved lands, and to browsing by deer, which are crowded into ever-diminishing habitat. The importance of preserving what remains of central New Jersey's native flora in the Sourlands region cannot be overstated.

Table 13 - New Jersey Endangered Plant Species and Plant Species of Concern Documented in the Sourlands Region

Allegheny vine	Adlumia fungosa	SMP, B
Arrow-leaved aster	Aster sagittifolius	B
Britton's grooveburr	Agrimonia striata	ACWMA
Giant yellow hyssop	Agastache nepitoides	SMP, B
Ginseng	Panax quinquefolius	SMP, B
Green violet	Hybanthus concolor	B
Hairy rock cress	Arabis hirsuta	B
Pennywort	Obolaria virginica	SMP
Redbud	Cercis canadensis	SMP, B
Slender toothwort	Cardamine angustata	SMP
Smooth hedge-nettle	Stachys tenuifolia	B
Spreading chervil	Chaerophyllum procumbens	B
Strict blue-eyed grass	Sisyrinchium montanum	ACWMA
Warty spike rush	Eleocharis tenuis var. Verrucosa	SMP
Wild comfrey	Cynoglossum virginianum	SMP
Winged monkey flower	Mimulus alatus	SMP

ACWMA = Alexauken Creek Wildlife Management Area
B = Baldpate Mountain
SMP = Sourland Mountain Preserve

<u>Habitat Management</u>

Careful management of the habitat in the Sourland region is critical to maintaining the biodiversity that exists. The interplay of habitat types in the area is what supports the incredible richness of plants and animals (Appendices 3 through 7.) As land acquisition continues, management plans should be developed to support habitat that preserves diversity. In some cases, this may include the creation of grassland habitat from cropland or pastureland. In other cases, old fields may need to be maintained at their early successional stage to provide shrub/scrub habitat. Other old fields will need to be left alone to progress to forest.

Of these management scenarios, grassland habitat maintenance will require the most intensive management plans. Former hayfields may need to be burned and replanted with native warm season grasses and a strict mowing regimen put in place. Invasive plants such as Canada thistle and crown vetch may need to be eliminated. Conversion to proper grassland habitat takes 3 or 4 growing seasons. Shrub-scrub habitat must be vigorously managed by selective mowing unless targeted for eventual succession to woodland. Typically, a new second growth forest requires 40 to 50 years to close its canopy sufficiently to eliminate invasive species that appear in almost every woodland in the region.

If native plant populations, critical forest understory and seedling trees needed for forest regeneration are to thrive, the complex and sensitive question of deer management needs to be addressed. Current deer populations far exceed those that existed before the eastern United States was converted from a vast forest to woodland patches amidst a sea of development and farmland. Deer inhabit forest edges more than they do the deep interior and exploit the banquet laid out for them by man. They are having a profound impact on our native vegetation. Studies in the northeastern states have shown that deer browsing of tree seedlings is driving the composition of our forests from mixed oak-hickory to red maple. In other words, deer are eating our hardwoods to potential extinction, and are creating a monoculture of red maple. There is a huge body of literature that supports this theory. And in a study conducted in the Sourlands as part of her 1995 Master's Thesis for Princeton University's Department of Ecology and Evolutionary Biology, S. E. Graham found that deer are effecting change in the composition of the forest.

Deer have decimated the ground covers of trillium, orchids and other wildflowers that used to carpet the forest floors in our state and that provided hiding places for ground-nesting Neotropical birds. According to Hannah Suthers, who has conducted extensive botanical studies at her bird banding station in Hopewell Township, deer have eaten the fringed orchis colony before it could go to seed, and have eaten down the cardinal flowers, a favorite nectar plant of hummingbirds, in bud. These plants lost their reproductive potential as a result. Suthers states that colonies of trout lily and ferns, which deer are more likely to avoid, actually indicate deer degenerated areas. A resident whose homestead is on the edge of the Sourland Mountain forest provides a graphic description of deer damage on his 16-acre property. Emmerson Bowes tells of the "complete disappearance of a stand of Ground Pine about 150' x 200' feet solid, all the Cardinal flowers from the edges of the rocky vernal ponds, and all Partridgeberry and Dwarf Ginseng have gone." He also reports near-extirpation of May apple, bloodroot, baneberry, wood anemone and rue anemone—all native woodland plants. He adds, "For the first time all Showy Orchis were eaten down to the ground this year as soon as the flowers opened." On his property, even "acres and acres of Trout Lily that one could not avoid treading on are down to miserable looking leaves and this year I spotted, instead of hundreds, just four flowers and those in a sheltered spot."

A deer management plan was initiated on Baldpate Mountain in January 2000. Each season since then, 85 to 90 participants holding special permits have harvested about 120 deer. As of the 2003-2004 hunting season, approximately 650 deer have been taken. There are about 33 hunting days in each season under the plan. Though several observers report that the ground layer vegetation appears to be regenerating since deer management began, there has not been a controlled study to evaluate the effect of the harvest on the herbaceous and understory layers of the forest. Such a study would have merit in mapping out a management plan.

Maintenance of the existing high-quality habitats in the Sourlands, as well as enhancement of those of lesser quality and even creation of new areas of suitable habitat will be of tremendous benefit to central New Jersey's native flora and fauna and essential to the stewardship of habitat for migratory birds for which the Sourlands region is a critical stopover site.

New Jersey Landscape Project

In 1993, the New Jersey Department of Environmental Protection's Endangered and Nongame Species Program (ENSP) initiated a move to a landscape level approach for endangered species protection. With suburbanization and development occurring in all areas of the State, an increasing amount of habitat that could potentially support threatened and endangered species was being lost daily.

In order to address habitat loss, ENSP needed to grasp the extent and suitability of remaining resources in the State. To accomplish this, they partnered with the Center for Remote Sensing and Spatial Analysis (CRSSA) at Cook College, Rutgers University. Utilizing LandSat Thematic Mapper satellite imagery, CRSSA mapped land cover for the entire State of New Jersey, broken down into 20 different habitat/land cover types. After generalized cover types were classified, detailed methodologies were developed to address the habitat suitability issues for each focus category, including beach/dunes, emergent landscapes, forested wetlands, forested areas and grasslands. Version 2 of the Landscape Project data, released in February of 2004 and presented in Figure 25, replaced the land cover information compiled by Rutgers with the 1995 land use/land cover data prepared by the New Jersey Department of Environmental Protection. Once the 2002 land use/land cover data for New Jersey is complete, it will replace the 1995 information.

After reclassifying data based on standards developed for each category, the habitat data was intersected or combined with the Natural Heritage Program's Biological Conservation Database (BCD). This database is a Geographic Information System (GIS) coverage that provides information on the sighting of threatened and endangered species, based on the field work of ENSP scientists and sightings reported by members of the public. It is the most comprehensive data available in digital form on the location of threatened and endangered species.

The Landscape Program data provides users with scientifically sound, peer-reviewed information on the location of critical habitat based on the conservation status of the species that are present. Habitats are ranked on a scale of 1 to 5, based on the following criteria:

Table 14 - NJ Landscape Program Ranking System

Rank	Indication
1	Suitable habitat, no special concern, threatened or endangered species sighted
2	Habitat patch with species of special concern present
3	Habitat patch with State threatened species present
4	Habitat patch with State endangered species present
5	Habitat patch with Federal threatened or endangered species present

The Sourland Mountain region is rich in habitat suitable to support populations of threatened and endangered species, as depicted on Figure 25. This includes forest, grassland, emergent and forested wetland areas that canvas the study area. The highest concentration of valuable habitat is along the Sourland ridge. Table 11 summarizes the area of each habitat type by rank.

Table 15 - NJ Landscape Project Habitat Summary

Habitat Type	Rank	Acres	% of Total Acres of Habitat Type
Grassland	1 – Suitable habitat	3,282.0	22.5
	2 – Species of Special Concern sighted	8,210.7	56.2
	3 – State Threatened Species sighted	1,236.8	8.5
	4 – State Endangered Species sighted	1,869.2	12.8
	Total	**14,598.7**	
Forested Wetland	1 – Suitable habitat	1,704.2	26.7
	2 – Species of Special Concern sighted	2,660.8	41.6
	3 – State Threatened Species sighted	2,024.6	31.7
	Total	**6,389.7**	
Forest	1 – Suitable habitat	752.4	2.5
	2 – Species of Special Concern sighted	11,557.8	39.0
	3 – State Threatened Species sighted	17,323.7	58.5
	4 – State Endangered Species sighted	3.41	0.0
	Total	**29,637.4**	
Emergent	1 – Suitable habitat	425.7	68.0
	2 – Species of Special Concern sighted	200.67	32.0
	Total	**626.34**	

The critical forest habitat of the Sourland Mountain supporting state threatened species stretches from the northern boundary of the study area in Hillsborough southwest along the mountain to

Route 31. It penetrates a portion of the lower lying elevations as well, situated on both the north and south facing slopes. Altogether, forested areas with documented sighting of state threatened species cover 17,323.7 acres and account for 31.4% of the study area. West of Route 31, the forest areas are documented as supporting a number of species of special concern. Comprising 11,557.8 acres (21%) of the study area, these forested areas stretch along the Sourland ridge just south of Lambertville City and cover Baldpate and Pennington Mountains. These lands are uniquely suited to reproducing populations of Neotropical migrating birds.

Grasslands supporting populations of state endangered species are present on the north side of the Sourland ridge in East Amwell extending south to the fringe of the study area. Part of the Natural Heritage Program's East Amwell Grasslands Macrosite, this habitat patch contains 1,869.2 acres. Other grassland habitats supporting populations of state threatened species are located along the study area boundary in southern Hopewell Township and northeast of Hopewell Borough straddling the Montgomery/Hopewell Township border. Together, these areas cover 1,236.8 acres. There are also large areas of grasslands which support state species of special concern (8.210.7 acres) and those which are suitable to support threatened or endangered species (3,282.0 acres) but have had no field survey incorporated into the Natural Heritage Program databaseAll grassland habitats are primarily associated with active agricultural operations which likely involve the production of hay or other grass-like crops.

The study area also has critical emergent and forested wetland habitat. These habitats are not as high ranking and expansive as the forest and grassland habitats, yet are nonetheless worthy of noting. Emergent habitat supporting state species of special concern cover 200.6 acres in the study area and are situated south and west of Hopewell Borough. Additional areas of emergent habitat identified by the Landscape Project as suitable to support threatened and endangered species yet lacking in field survey are found north and south of County Route 601 in both West Amwell and Hopewell townships. Emergent habitats are critical to the reproductive cycles of many amphibian species, reliant on both emergent wetlands and spring (vernal) pools for this process. The NJDEP, in cooperation with The Center for Remote Sensing and Spatial Analysis (CRSSA) at Cook College developed a project to identify and monitor vernal habitats, which will eventually be incorporated in the Landscape Project data. New regulations adopted in 2001 afford protection to emergent and vernal habitats where previously none existed. This lack of protection was largely due to the size of pools and isolated emergent areas, as many are less than 1 acre and could be drained and filled with a general wetland permit. CRSSA and NJDEP are developing maps of both potential and certified vernal and emergent habitats. In addition to study underway by NJDEP and CRSSA, volunteer organizations and experts from non-profit groups have taken on the issue of identifying vernal pools in the Sourland region, although no map products are available and documentation is lacking at this point.

Much of the forested wetland habitat depicted on Figure 25 supports populations of threatened and state special concern species. Covering 2,024.6 acres, habitat with documented sightings of state threatened species are present along the Sourland ridge in Hillsborough, East Amwell and Hopewell townships. When combined with upland forest critical habitat of the same rank, the area encompasses nearly 20,000 acres. Forested wetland supporting state species of special concern covers 2,660.8 acres and is located both on the Sourland ridge and on facing slopes straddling the mountain itself. Habitat suitable to support threatened and endangered species but with no field survey covers 1,704.2 acres primarily located west of Route 31.

The Landscape Project data is intended to aid municipalities, County and State governments, conservation agencies and citizens in determining the extent of critical habitat within their respective jurisdictions and communities. After identifying critical habitat, a variety of means can be employed to protect it, including the following:

- Prioritizing open space acquisitions based on the presence of habitat for threatened and endangered species
- Adopting regulations aimed at protecting critical habitat
- Adopting management policies for open space that are consistent with protection of critical habitat
- Permitting flexibility in development techniques that can accommodate the protection of critical habitat
- Promoting land stewardship practices that are consistent with the protection of critical habitat

APPENDICES

APPENDIX 1 - Geologic Units – Technical Descriptions[vi]

Jd, Jg Diabase and granophyre (Early Jurassic) – Fine-grained to aphanitic dikes; medium- to coarsegrained, subophitic discordant stock-like intrusions of dark-greenish-gray to black Diabase; and plugs of dark gray, concordant to discordant sheetlike, medium- to coarse-grained, quartz-rich to albite-rich granophyre (map unit Jg). The chilled margins of Diabase masses are aphanitic to very fine grained. Diabase is dense, hard, and sparsely fractured. It is composed mostly of plagioclase (An50-70), clinopyroxene (mostly augite) and magnetite±ilmenite. Accessory minerals include apatite, quartz, alkali feldspar, hornblende, titantite, and zirocon. Olivine is rare. Within about 200 m (655 ft) above and 150 m (490 ft) below the large Diabase sheets, red mudstones are typically metamorphosed into indurated, bluish-gray hornfels commonly with clots or crystals of tourmaline or cordierite, whereas argillitic siltstone is metamorphosed into brittle, black, very fine grained hornfels, Sheetlike intrusions are as much as 360 to 400 m (1,180-1,310 ft) thick. Dikes range in thickness from 3 to 15 m (10-50 ft) and several kilometers (miles) long. Thickness of the stocklike bodies is unknown.

JTrp, JTrpms, JTrps, JTrpsc, JTrpcq, JTrpcl, Trpg Passaic Formation (Lower Jurassic and Upper Triassic) (Olsen, 1980) - Reddish-brown to brownish-purple and grayish-red siltstone and shale (JTrp) maximum thickness 3,600 m (11,810 ft). At places contains mapped sandy mudstone (JTrpms), sandstone (JTrps), conglomeratic sandstone (JTrpsc) and conglomerate containing clasts of quartzite (JTrpcq), or limestone (JTrpcl). Formation coarsens up section and to the southwest. Quartzite conglomerate unit (JTrpcq) is reddish-brown pebble conglomerate, pebbly sandstone, and sandstone, in upward-fining sequences 1 to 2 m (3-6 ft) thick. Clasts are subangular to subrounded, quartz and quartzite in sandstone matrix. Sandstone is medium to coarse grained, feldspathic (up to 20 percent feldspar), and locally contains pebble and cobble layers. Conglomerate thickness exceeds 850 m (2,790 ft). Limestone conglomerate unit (JTrpcl) is medium-bedded to massive, pebble to boulder conglomerate. Clasts are subangular dolomitic limestone in matrix of brownish- to purplish-red sandstone to mudstone; matrix weathers light-gray to white near faults. Maximum thickness unknown.

Trl, Trlr, Trla, Trls, Trlcq Lockatong Formation (Upper Triassic) (Kümmel, 1897) - Cyclically-deposited sequences consisting of light- to dark-gray, greenish-gray, and black, dolomitic or analcime-bearing silty argillite, laminated mudstone, silty to calcareous, argillaceous, very-fine-grained pyritic sandstone and siltstone, and minor silty limestone (Trl). Grayish-red, grayish-purple, and dark-brownish-red sequences (Trlr) common in upper half. Two types of cycles are recognized: detrital and chemical.

Detrital cycles average 5.2 m (17 ft) thick and consist of basal, argillaceous, very fine grained sandstone to coarse siltstone; medial, dark-gray to black, laminated siltstone, silty mudstone, or silty limestone; and upper, light- to dark-gray, silty to dolomitic or analcime-rich mudstone, argillitic siltstone, or very-finegrained sandstone. Chemical cycles are similar to detrital cycles, but thinner, averaging 3.2 m (10.5 ft). Cycles in northern Newark basin are thinner and have arkosic sandstone in lower and upper parts. Upper part of formation in northern basin composed mostly of light-gray to light-pinkish-gray or light-brown, coarse- to fine-grained, thick- to massive-bedded arkosic sandstone (Trla). Thermally metamorphosed into hornfels where intruded by Diabase (Jd). Interfingers laterally and gradationally with quartz sandstone and conglomerate (Trls) and quartzite conglomerate (Trlcq) near Triassic border fault in southwestern area of map. Maximum thickness of Lockatong Formation about 1,070 m (3,510 ft).

Trs, Trss, Trscq Stockton Formation (Upper Triassic) (Kümmel, 1897) - Light-gray, light-grayishbrown, yellowish- to pinkish-gray, or violet-gray to reddish-brown, medium- to coarse-grained arkosic sandstone and reddish- to purplish-brown mudstone, silty mudstone, argillaceous siltstone, and shale. Mudstone, siltstone and shale beds thicker and more numerous in central Newark basin west of Round Valley Reservoir. Sandstones mostly planar-bedded, with scoured bases containing pebble lags and mudstone rip-ups. Unit is coarser near Newark basin border fault, where poorly exposed, reddish-brown to pinkish-white, medium- to coarse-grained, feldspathic pebbly sandstone and conglomerate (Trss) and pebble to cobble quartzite conglomerate (Trscq). Maximum thickness of formation about 1,240 m (4,070 ft).

APPENDIX 2 – SSURGO Data for Soils in the Sourland Mountain Region

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Symbol	Soil Name	Highly Erodible Lands Class(1)	Total Acres	Farmland Capability	N.J.A.C. 7:9A Soil Suitability Classifications	Depth to Seasonal High Water	Depth to Bedrock
AbrA	Abbottstown silt loam, 0 to 3 percent slopes	2	160.0	Statewide Important Soil	IIIHr, Wp(IISc); IISr, Wp (IISc)	0.5 to 1.5 Feet	40 to 60 Inches
AbrB	Abbottstown silt loam, 3 to 8 percent slopes	2	668.5	Statewide Important Soil	IIIHr, Wp(IISc); IISr, Wp (IISc)	0.5 to 1.5 Feet	40 to 60 Inches
BhmB	Birdsboro loam, 3 to 8 percent slopes	2	49.2	Prime Soil	I; IIWr; IISc; IIWrSc	0 Feet	0 Inches
BhmB2	Birdsboro loam, 3 to 8 percent slopes, eroded	2	45.2	Prime Soil	I; IIWr; IISc; IIWrSc	0 Feet	0 Inches
BhmC2	Birdsboro loam, 8 to 15 percent slopes, eroded	1	6.8	Statewide Important Soil	I; IIWr; IISc; IIWrSc	0 Feet	0 Inches
BhnA	Birdsboro silt loam, 0 to 3 percent slopes	3	34.1	Prime Soil	I; IIWr; IISc; IIWrSc	0 Feet	0 Inches
BhnB	Birdsboro silt loam, 3 to 8 percent slopes	2	106.9	Prime Soil	I; IIWr; IISc; IIWrSc	4 Feet	60 Inches
Boy	Bowmansville silt loam	3	776.7	Statewide Important Soil	IIIWr	0 to 1 Feet	72 to 99 Inches
BucA	Bucks silt loam, 0 to 3 percent slopes	3	218.7	Prime Soil	IISc; IISr	0 Feet	40 Inches
BucB	Bucks silt loam, 3 to 8 percent slopes	2	2,324.7	Prime Soil	IISc; IISr	6 Feet	40 Inches
BucB2	Bucks silt loam, 3 to 8 percent slopes, eroded	2	128.0	Prime Soil	IISc; IISr	0 Feet	40 Inches
BucC	Bucks silt loam, 8 to 15 percent slopes	2	233.6	Statewide Important Soil	IISc; IISr	0 Feet	40 Inches
BucC2	Bucks silt loam, 8 to 15 percent slopes, eroded	2	520.3	Statewide Important Soil	IISc; IISr	6 Feet	40 Inches
CakBb	Califon loam, 0 to 8 percent slopes, very stony	2	25.2		IIIHrWp	0.5 to 2.5 Feet	60 Inches
ChcA	Chalfont silt loam, 0 to 3 percent slopes	2	996.4	Statewide Important Soil	IIISrWp	0.5 to 1.5 Feet	40 to 60 Inches
ChcB	Chalfont silt loam, 3 to 8 percent slopes	2	5,552.6	Statewide Important Soil	IIISrWp	0.5 to 1.5 Feet	40 Inches
ChcB2	Chalfont silt loam, 3 to 8 percent slopes, eroded	2	510.0	Statewide Important Soil	IIISrWp	0 Feet	40 Inches
ChcBa	Chalfont silt loam, 0 to 8 percent slopes, stony	2	510.3		IIISrWp	0.5 to 1.5 Feet	40 Inches
ChcBb	Chalfont silt loam, 0 to 8 percent slopes, very stony	2	105.6		IIISrWp	0 Feet	40 Inches
ChcC	Chalfont silt loam, 8 to 15 percent slopes	1	621.3	Statewide Important Soil	IIISrWp	0.5 to 1.5 Feet	40 Inches
ChcC2	Chalfont silt loam, 8 to 15 percent slopes, eroded	1	2,190.3	Statewide Important Soil	IIISrWp	0.5 to 1.5 Feet	40 to 60 Inches
ChcCa	Chalfont silt loam, 8 to 15 percent slopes, stony	1	778.8		IIISrWp	0.5 to 1.5 Feet	40 Inches
ChcCb	Chalfont silt loam, 0 to 15 percent slopes, very stony	2	147.4		IIISrWp	0.5 to 1.5 Feet	40 to 60 Inches
ChcDa	Chalfont silt loam, 15 to 25 percent slopes, stony	1	630.2		IIISrWp	0.5 to 1.5 Feet	40 Inches
CheCb	Chalfont-Lehigh silt loams, 8 to 15 percent slopes, very stony	2	695.3		IIISrWp	0.5 to 1.5 Feet	40 to 60 Inches
ChfB	Chalfont-Quakertown silt loams, 0 to 8 percent slopes	2	26.5	Statewide Important Soil	IIISrWp	0.5 to 1.5 Feet	40 to 60 Inches
CoxA	Croton silt loam, 0 to 3 percent slopes	2	233.0	Statewide Important Soil	IIISrWp; IIISrWr	0 to 0.5 Feet	42 to 60 Inches
CoxB	Croton silt loam, 3 to 8 percent slopes	2	149.9	Statewide Important Soil	IIISrWp; IIISrWr	0 to 0.5 Feet	42 to 60 Inches
CoxBb	Croton silt loam, 0 to 8 percent slopes, very stony	2	3.5		IIISrWp; IIISrWr	0 to 1 Feet	40 to 60 Inches
DOZA	Doylestown silt loam and Reaville Variant silt loam, 0 to 3 percent slopes	2	404.3		IIISrWr	0 to 0.5 Feet	40 Inches
DOZB	Doylestown silt loam and Reaville Variant silt loam, 3 to 8 percent slopes	2	451.8		IIISrWr	0 to 0.5 Feet	40 Inches
DOZB2	Doylestown silt loam and Reaville Variant silt loam, 3 to 8 percent slopes, eroded	2	47.0		IIISrWr	0 to 0.5 Feet	40 Inches
DOZC	Doylestown silt loam and Reaville Variant silt loam, 8 to 15 percent slopes	1	42.5		IIISrWr	0 to 0.5 Feet	40 Inches

APPENDIX 2 - SSURGO Data for Soils in the Sourland Mountain Region

Symbol	Soil Name	Highly Erodible Lands Class(1)	Total Acres	Farmland Capability	N.J.A.C. 7:9A Soil Suitability Classifications	Depth to Seasonal High Water	Depth to Bedrock
HdyB	Hazelton channery loam, 3 to 8 percent slopes	2	27.7		IISc	6 Feet	48 to 60 Inches
HdyB2	Hazelton channery loam, 8 to 15 percent slopes, eroded	2	98.4		IISc	6 Feet	48 to 60 Inches
HdyD	Hazelton channery loam, 15 to 25 percent slopes	1	91.0		IISc	6 Feet	48 to 60 Inches
HdzEb	Hazelton loam, 25 to 45 percent slopes, very stony	1	74.6		IISc	6 Feet	48 to 60 Inches
KkoC	Klinesville channery loam, 8 to 15 percent slopes	2	1,246.1		IISc; IISr	6 Feet	10 to 20 Inches
KkoD	Klinesville channery loam, 15 to 25 percent slopes	1	287.2		IISc; IISr	6 Feet	10 to 20 Inches
KkoE	Klinesville channery loam, 25 to 45 percent slopes	1	173.9		IISc; IISr	6 Feet	10 to 20 Inches
LDXA	Lawrenceville and Mount Lucas silt loams, 0 to 3 percent slopes	2	21.1	Prime Soil	IIISrWp; IIIHrWp	0 Feet	48 Inches
LDXB	Lawrenceville and Mount Lucas silt loams, 3 to 8 percent slopes	2	328.3	Prime Soil	IIISrWp; IIIHrWp	0 Feet	48 Inches
LDXB2	Lawrenceville and Mount Lucas silt loams, 3 to 8 percent slopes, eroded	2	94.6	Prime Soil	IIISrWp; IIIHrWp	0 Feet	48 Inches
LDXC2	Lawrenceville and Mount Lucas silt loams, 8 to 15 percent slopes, eroded	1	113.6	Statewide Important Soil	IIISrWp; IIIHrWp	0 Feet	48 Inches
LbhB	Lansdale sandy loam, 3 to 8 percent slopes	2	57.6	Prime Soil	IISc	0 Feet	42 to 60 Inches
LbmB	Lansdale loam, 3 to 8 percent slopes	2	20.6	Prime Soil	IISc	6 Feet	40 to 60 Inches
LbmCb	Lansdale loam, 0 to 15 percent slopes, very stony	2	48.4		IISc	0 Feet	40 to 60 Inches
LbmEb	Lansdale loam, 25 to 45 percent slopes, very stony	1	3.7		IISc	0 Feet	40 to 60 Inches
LbnC2	Lansdale channery loam, 8 to 15 percent slopes, eroded	2	81.6	Statewide Important Soil	IISc	0 Feet	42 to 60 Inches
LbnD2	Lansdale channery loam, 15 to 25 percent slopes	1	51.8		IISc	0 Feet	42 to 60 Inches
LbtA	Lansdowne silt loam, 0 to 3 percent slopes	2	53.5	Statewide Important Soil	IISc	1 to 2.5 Feet	48 Inches
LbtB	Lansdowne silt loam, 3 to 8 percent slopes	2	23.4	Statewide Important Soil	IISc	1 to 2.5 Feet	48 Inches
LdmB	Lawrenceville silt loam, 3 to 8 percent slopes	2	1,822.6	Prime Soil	IIISrWp; IIIHrWp	1.5 to 3 Feet	48 Inches
LdmC	Lawrenceville silt loam, 8 to 15 percent slopes	1	285.4	Statewide Important Soil	IIISrWp; IIIHrWp	1.5 to 3 Feet	48 Inches
LdmC2	Lawrenceville silt loam, 8 to 15 percent slopes, eroded	1	287.7	Statewide Important Soil	IIISrWp; IIIHrWp	1.5 to 3 Feet	40 to 60 Inches
LegB	Legore gravelly loam, 3 to 8 percent slopes	2	6.5	Prime Soil	I; IISr	6 Feet	48 to 60 Inches
LegC	Legore gravelly loam, 8 to 15 percent slopes	2	313.7	Statewide Important Soil	I; IISr	6 Feet	48 to 60 Inches
LegD	Legore gravelly loam, 15 to 25 percent slopes	1	414.3		I; IISr	6 Feet	48 to 60 Inches
LegE	Legore gravelly loam, 18 to 30 percent slopes	1	713.9		I; IISr	0 Feet	48 to 60 Inches
LemB	Lehigh silt loam, 3 to 8 percent slopes	2	1,557.1	Statewide Important Soil	IIISrWp; IIIHrWp(IISc)	0.5 to 2 Feet	40 to 60 Inches
LemB2	Lehigh silt loam, 3 to 8 percent slopes, eroded	2	71.8	Statewide Important Soil	IIISrWp; IIIHrWp(IISc)	0 Feet	40 to 60 Inches
LemBb	Lehigh silt loam, 0 to 8 percent slopes, very stony	2	139.4		IIISrWp; IIIHrWp(IISc)	0.5 to 2 Feet	40 to 60 Inches
LemC	Lehigh silt loam, 8 to 15 percent slopes	1	289.4	Statewide Important Soil	IIISrWp; IIIHrWp(IISc)	0.5 to 2 Feet	40 to 60 Inches
LemC2	Lehigh silt loam, 8 to 15 percent slopes, eroded	1	1,196.6	Statewide Important Soil	IIISrWp; IIIHrWp(IISc)	0.5 to 2 Feet	40 to 60 Inches
LemD2	Lehigh silt loam, 15 to 25 percent slopes, eroded	1	320.6		IIISrWp; IIIHrWp(IISc)	0.5 to 2 Feet	40 to 60 Inches
LemDb	Lehigh silt loam, 8 to 15 percent slopes, very stony	2	168.8		IIISrWp; IIIHrWp(IISc)	0.5 to 2 Feet	40 to 60 Inches
MORCB	Mount Lucas and Neshaminy soils, 8 to 15 percent slopes, very stony	2	120.5		IIIWp(IISr)	0 Feet	48 to 99 Inches
MonB	Mount Lucas silt loam, 3 to 8 percent slopes	2	244.6	Prime Soil	IIIWp(IISr)	0.5 to 2.5 Feet	48 to 60 Inches
MonBb	Mount Lucas silt loam, 0 to 8 percent slopes, very stony	2	175.6		IIIWp(IISr)	0 Feet	48 to 99 Inches
MonCb	Mount Lucas silt loam, 8 to 15 percent slopes, very stony	1	75.8		IIIWp(IISr)	0 Feet	48 to 99 Inches

APPENDIX 2 - SSURGO Data for Soils in the Sourland Mountain Region

Symbol	Soil Name	Highly Erodible Lands Class(1)	Total Acres	Farmland Capability	N.J.A.C. 7:9A Soil Suitability Classifications	Depth to Seasonal High Water	Depth to Bedrock
MopBb	Mount Lucas-Watchung silt loams, 0 to 8 percent slopes, very stony	2	3,163.3		IIIWp(IISr)	0.5 to 2.5 Feet	48 to 60 Inches
MopCb	Mount Lucas-Watchung silt loams, 8 to 15 percent slopes, very stony	2	609.2		IIIWp(IISr)	0.5 to 2.5 Feet	48 to 99 Inches
NehB	Neshaminy silt loam, 3 to 8 percent slopes	2	982.5	Prime Soil	IISr	6 Feet	48 to 99 Inches
NehC	Neshaminy silt loam, 8 to 15 percent slopes	2	81.1	Statewide Important Soil	IISr	6 Feet	48 to 99 Inches
NehC2	Neshaminy silt loam, 8 to 15 percent slopes, eroded	2	318.5	Statewide Important Soil	IISr	6 Feet	48 to 60 Inches
NehCb	Neshaminy silt loam, 8 to 15 percent slopes, very stony	2	587.8		IISr	6 Feet	48 to 60 Inches
NehDb	Neshaminy silt loam, 15 to 25 percent slopes, very stony	1	679.2		IISr	6 Feet	48 to 60 Inches
NehEb	Neshaminy silt loam, 25 to 45 percent slopes, very stony	1	570.7		IISr	6 Feet	48 to 60 Inches
NehEc	Neshaminy silt loam, 25 to 45 percent slopes, extremely stony	1	31.1		IISr	0 Feet	48 Inches
NemCb	Neshaminy-Mount Lucas silt loams, 8 to 15 percent slopes, very stony	2	2,838.2		IISr	0.5 to 3 Feet	48 to 99 Inches
NemDb	Neshaminy-Mount Lucas silt loams, 15 to 25 percent slopes, very stony	1	228.7		IISr	0.5 to 3 Feet	48 to 99 Inches
NotB	Norton loam, 3 to 8 percent slopes	2	79.7	Prime Soil	IIIHr	6 Feet	42 Inches
PHF	Pits, gravel	3	1.9		Disturbed Ground	6 Feet	60 Inches
PHG	Pits, sand and gravel	3	57.1		Disturbed Ground	0 Feet	0 Inches
PenB	Penn silt loam, 3 to 8 percent slopes	2	251.1	Prime Soil	IISc; IIISr	6 Feet	20 to 40 Inches
PenC	Penn silt loam, 8 to 15 percent slopes	1	10.7	Statewide Important Soil	IISc; IIISr	6 Feet	20 to 40 Inches
PeoB	Penn channery silt loam, 3 to 8 percent slopes	2	1,767.1	Prime Soil	IISc; IIISr	6 Feet	20 to 40 Inches
PeoC	Penn channery silt loam, 8 to 15 percent slopes	1	1,182.1		IISc; IIISr	6 Feet	20 to 40 Inches
PeoC2	Penn channery silt loam, 8 to 15 percent slopes, eroded	2	1,164.2		IISc; IIISr	6 Feet	20 to 40 Inches
PeoD	Penn channery silt loam, 15 to 25 percent slopes	1	385.7		IISc; IIISr	6 Feet	20 to 40 Inches
PepB	Penn-Bucks complex, 3 to 8 percent slopes	2	205.1	Prime Soil	IISc; IIISr	6 Feet	40 to 60 Inches
PepC2	Penn-Bucks complex, 8 to 15 percent slopes, eroded	2	76.3	Statewide Important Soil	IISc; IIISr	6 Feet	40 to 60 Inches
PomA	Pope fine sandy loam, high bottom, 0 to 3 percent slopes	3	3.8	Prime Soil	I; IISc	6 Feet	60 Inches
QY	Quarry	3	27.1		Disturbed Ground	6 Feet	0 Inches
QukB	Quakertown silt loam, 3 to 8 percent slopes	2	1,610.6	Prime Soil	IISc; I	6 Feet	40 to 60 Inches
QukB2	Quakertown silt loam, 3 to 8 percent slopes, eroded	2	165.9	Prime Soil	IISc; I	0 Feet	42 to 60 Inches
QukC	Quakertown silt loam, 8 to 15 percent slopes	2	583.2	Statewide Important Soil	IISc; I	6 Feet	42 to 60 Inches
QukC2	Quakertown silt loam, 8 to 15 percent slopes, eroded	1	511.8	Statewide Important Soil	IISc; I	6 Feet	40 to 60 Inches
QukD	Quakertown silt loam, 15 to 25 percent slopes	1	247.4		IISc; I	6 Feet	42 to 60 Inches
QukD2	Quakertown silt loam, 15 to 25 percent slopes, eroded	1	40.6		IISc; I	6 Feet	40 to 60 Inches
QumB	Quakertown channery silt loam, 3 to 8 percent slopes	2	224.8	Prime Soil	IISc	0 Feet	42 to 60 Inches
QumC	Quakertown channery silt loam, 8 to 15 percent slopes	1	131.2	Statewide Important Soil	IISc	0 Feet	42 to 60 Inches
QumC2	Quakertown channery silt loam, 8 to 15 percent slopes, eroded	1	177.7	Statewide Important Soil	IISc	0 Feet	42 to 60 Inches
QumD2	Quakertown channery silt loam, 15 to 25 percent slopes, eroded	1	122.7		IISc	0 Feet	42 to 60 Inches
REFA	Readington and Abbottstown silt loams, 0 to 3 percent slopes	2	62.2	Prime Soil	IIIHrWp(IISc); IIWpSrSc; IIWrSc	0 Feet	40 Inches
REFB	Readington and Abbottstown silt loams, 3 to 8 percent slopes	2	87.6	Prime Soil	IIIHrWp(IISc); IIWpSrSc; IIWrSc	0 Feet	40 Inches
REFB2	Readington and Abbottstown silt loams, 3 to 8 percent slopes, eroded	2	33.3	Prime Soil	IIIHrWp(IISc); IIWpSrSc; IIWrSc	0 Feet	40 Inches

APPENDIX 2 - SSURGO Data for Soils in the Sourland Mountain Region

Symbol	Soil Name	Highly Erodible Lands Class(1)	Total Acres	Farmland Capability	N.J.A.C. 7:9A Soil Suitability Classifications	Depth to Seasonal High Water	Depth to Bedrock
REFC2	Readington and Abbottstown silt loams, 8 to 15 percent slopes, eroded	1	37.8	Statewide Important Soil	IIIHrWp(IISc); IIWpSrSc; IIWrSc	0 Feet	40 Inches
RNG	Rough broken land, shale	1	696.6		Excessively Stony	6 Feet	0 Inches
RarA	Raritan silt loam, 0 to 3 percent slopes	2	3.4	Prime Soil	IIIHrWp; IIIHrWp(IISc); IIIHrWp(IISr)	0.5 to 2.5 Feet	60 Inches
RarB	Raritan silt loam, 3 to 8 percent slopes	2	19.6	Prime Soil	IIIHrWp; IIIHrWp(IISc); IIIHrWp(IISr)	0.5 to 2.5 Feet	60 Inches
RedB	Readington silt loam, 3 to 8 percent slopes	2	103.3	Prime Soil	IIIHrWp(IISc); IIWpSrSc; IIWrSc	1.5 to 3 Feet	40 Inches
RedC2	Readington silt loam, 8 to 15 percent slopes, eroded	1	30.3	Statewide Important Soil	IIIHrWp(IISc); IIWpSrSc; IIWrSc	1.5 to 3 Feet	40 to 60 Inches
RehA	Reaville silt loam, 0 to 3 percent slopes	2	290.4	Statewide Important Soil	IIISrWp(IIHc)	0.5 to 3 Feet	20 to 40 Inches
RehB	Reaville silt loam, 3 to 8 percent slopes	2	1,650.1	Statewide Important Soil	IIISrWp(IIHc)	0.5 to 3 Feet	20 to 40 Inches
RehB2	Reaville silt loam, 3 to 8 percent slopes, eroded	2	83.7	Statewide Important Soil	IIISrWp(IIHc)	0 Feet	20 to 40 Inches
RehC2	Reaville silt loam, 8 to 15 percent slopes, eroded	1	301.9	Statewide Important Soil	IIISrWp(IIHc)	1 to 2 Feet	20 to 40 Inches
RepwA	Reaville Wet Variant silt loam, 0 to 3 percent slopes	2	140.6		IIISrWp(IIHc)	0 to 1 Feet	20 to 40 Inches
RepwB	Reaville Wet Variant silt loam, 3 to 8 percent slopes	2	28.9		IIISrWp(IIHc)	0 to 1 Feet	20 to 40 Inches
RksC	Riverhead gravelly sandy loam, 8 to 15 percent slopes	2	2.7	Statewide Important Soil	I; IISc	6 Feet	60 Inches
Ror	Rowland silt loam	3	1,429.9	Farmland of Local Importance	IIIWr	1 to 3 Feet	72 Inches
RoyB	Royce silt loam, 3 to 8 percent slopes	2	129.2	Prime Soil	IISc	6 Feet	40 to 72 Inches
ThoA	Tioga fine sandy loam, 0 to 3 percent slopes	3	4.4	Prime Soil	I; IIWr:IIWrSc; IISc	0 Feet	0 Inches
UR	Urban land	3	51.7		Disturbed Ground	2 Feet	10 Inches
Udt	Udorthents, bedrock substratum	3	96.9			0 Feet	48 to 72 Inches
WATER	Water	1	147.8		Water	0 Feet	0 Inches
Was	Watchung silt loam	2	151.6		IIIHrWpWr	0 to 1 Feet	60 Inches
Wasb	Watchung silt loam, very stony	2	35.8		IIIHrWpWr	0 to 1 Feet	0 Inches
			55,233.8				

(1) 1= Highly Erodible, 2= Potentially Highly Erodible, 3= Not Highly Erodible

APPENDIX 3 – Exotic Invasive Plants[vii]

LARGE TREES

Common Name	***Scientific Name***
Amur Maple	*Acer ginnala*
Japanese Red Maple	*Acer japonica*
Norway Maple	*Acer platanoides*
Sycamore Maple	*Acer psuedoplatanus*
Tree-of-Heaven	*Ailanthus altissima*
Black Alder	*Alnus glutinosa*
Paper Mulberry	*Broussonetia papyrifera*
Autumn Olive	*Eleagnus umbellatus*
Russian Olive	*Eleagnus angustifolia*
Golden Rain Tree	*Koelreuteria paniculata*
Chinaberry	*Melia Azedarach*
White Mulberry	*Morus alba*
Empress Tree	*Paulownia tomentosa*
Amur Corktree	*Phellodendron amurense*
White Cottonwood	*Populus alba*
Sweet Cherry	*Prunus avium*
Siberian Elm	*Ulmus pumila*
Chinese Tallow Tree	*Sapium sebiferum*

SHRUBS & SMALL TREES

Common Name	***Scientific Name***
Mimosa	*Albizia julibrissin*
Barberry	*Berberis japonica*
Barberry	*Berberis thunbergii*
Scotch Broom	*Cystisus scoparius*
Russian Olive	*Elaeagnus angustifolia*
Thorny Olive	*Elaeagnus pungens*
Autumn Olive	*Eleagnus umbellata*
Winged Euonymus	*Euonymus alatus*
Rose-of-Sharon	*Hibiscus syriacus*
Border Privet	*Ligustrum obtusifolium*
Chinese Privet	*Ligustrum sinense*
Amur Honeysuckle	*Lonicera maackii*
Morrow's Honeysuckle	*Lonicera morrowii*
Tartarian Honeysuckle	*Lonicera tatarica*
Belle Honeysuckle	*Lonicera x bella*
Common Buckthorn	*Rhamnus cathartica*
European Buckthorn	*Rhamnus frangula*
Multiflora Rose	*Rosa multiflora*
Cut Leaved Blackberrry	*Rubus laciniata*
Wineberry	*Rubus phoenicolasius*
Japenese Spirea	*Spiraea japonica*

VINES AND GROUNDCOVERS

Common Name	***Scientific Name***
Fiveleaf Akebia	*Ampelopsis brevipedunculata*
Chinese Bittersweet	*Celastrus orbiculatus*
Climbing Euonymus	*Euonymus fortunei*
English Ivy	*Hedera helix*
Hops	*Humulus japonica*
Japanese Honeysuckle	*Lonicera japonica*
Silver Fleece Vine	*Polygonum aubertii*
Kudzu	*Pueraria lobata*
Bittersweet Nightshade	*Solanum dulcamara*
Periwinkle	*Vinca minor*
Wisteria	*Wisteria floribunda*
Chinese Wisteria	*Wisteria sinensis*

HERBACEOUS PLANTS

Common Name	***Scientific Name***
Yarrow	*Achillea millefolium*
Goutweed	*Aegopodium podagraria*
Rhode Island Bent Grass	*Agrostis capillaries*
Redtop	*Agrostis gigantean*
Bugleweed	*Ajuga reptans*
Garlic Mustard	*Alliara officinalis*
Wild Onion	*Allium vineale*
Burdock	*Arctium spp.*
Oatgrass	*Arrenatherum elatius*
Mugwort	*Artemisia vulgaris*
Giant Reed	*Arunddonaz*
Smooth Brome	*Bromus inermis*
Musk Thistle	*Carduus nutans*
Asiatic Sand Sedge	*Carex kobomugi*
Brown Knapweed	*Centaurea jucea*
Knapweed	*Centaurea nigrescens*
Chicory	*Cichorium intybus*
Bull Thistle	*Cirsium vulgare*
Canada Thistle	*Cirsium arvense*
Water Hemlock	*Conium macalatum*
Field Bindweed	*Convolvuus arvensis*
Tickseed	*Coreopsis lanceolata*
Crown Vetch	*Coronilla varia*
Bermuda Grass	*Cynodon dactylon*
Orchard Grass	*Dactylis glomerata*
Queen Anne's Lace	*Daucus carota*
Cut Leaf Teasel	*Dipsacus laciniatus*
Common Teasel	*Dipsacus sylvestris*
Chinese Yam	*Dioscorea batatas*
Quackgrass	*Elytrigia repens*
Hairy Willow Herb	*Epilobium hirsutum*
Weeping Lovegrass	*Eragrostis curvula*
Cypress Spurge	*Euphorbia cyparissias*
Leafy Spurge	*Euphorbia esula*

Common Name	***Scientific Name***
Tall Fescue	*Festuca arundinacea*
Fescue	*Festuca elatior*
Sheep Fescue	*Festuca ovina*
Fennel	*Foeniculum vulgare*
Field Madder	*Galium mollugo*
Ground Ivy	*Glechoma hederacea*
Day Lily	*Hemerocallis fulva*
Velvet Grass	*Holcus lanatus*
Hops	*Humulus japonica*
St. John's Wort	*Hypericum perforatum*
Cogan Grass	*Imperata cylindrical*
Yellow Iris	*Iris pseudacorus*
Chinese Lespedeza	*Lespedeza cuneata*
Butter & Eggs	*Linaria vulgaris*
Birdsfoot Trefoil	*Lotus corniculatus*
Money Wort	*Lysimachia nummularia*
Purple Loosestrife	*Lythrum salicaria*
Purple Loosestrife	*Lythrum virgatum*
White Sweet Clover	*Melilotus alba*
Yellow Sweet Clover	*Melilotus officinalis*
Miscanthus	*Miscanthus sinensis*
Wild Parsnip	*Pastinaca sativa*
Reed Canary Grass	*Phalaris arundinacea*
Timothy	*Phleum prantense*
Narrow Leave Plantain	*Plantago lanceolata*
Broad Leaved Plantain	*Plantago major*
Canada Bluegrass	*Poa compressa*
Rough Bluegrass	*Poa trivialis*
Lesser Calandine	*Ranunculus ficaria*
Japanese Knotweed	*Reynoutria japonica*
Broad Leaved Dock	*Rumes obtusifolia*
Johnson Grass	*Sorghum halepense*
Stinging Nettle	*Urtica dioica*
Flannel Leaved Mullein	*Verbascum thapsus*

APPENDIX 4 – Bird Species in the Sourland Region

Birds of Featherbed Lane Bird Banding Station
Sommer Park, Hopewell Sourlands
Hannah Suthers

Permanent Residents

Black-capped Chickadee	Carolina Chickadee
Eastern Tufted Titmouse	White-breasted Nuthatch
Carolina Wren	Canada Goose
Eastern Bluebird	Red-tailed Hawk
Northern Mockingbird	Bobwhite
Cedar Waxwing	Wild Turkey
Northern Cardinal	Ruffed Grouse
House Finch	House Sparrow
American Goldfinch	Hybrid Chickadee
Ring-necked Pheasant	Eastern Screech Owl
Great Horned Owl	Red-bellied Woodpecker
Downy Woodpecker	Northern Cardinal
Hairy Woodpecker	Pileated Woodpecker
American Crow	

Neotropical Migrants That Breed Here

Black-billed Cuckoo	Yellow-billed Cuckoo
Chimney Swift	Ruby-throated Hummingbird
Eastern Wood Pewee	Willow Flycatcher
Eastern Phoebe	Great Crested Flycatcher
Eastern Kingbird	Barn Swallow
Purple Martin	Blue-gray Gnatcatcher
Veery	Wood Thrush
Gray Catbird	White-eyed Vireo
Red-eyed Vireo	Yellow-throated Vireo
Blue-winged Warbler	

Short Distance Migrants That Breed Here

Turkey Vulture	some overwinter
Black Vulture	some overwinter
Red-shouldered Hawk	some overwinter
Am. Kestrel	
Am. Woodcock	
Killdeer	
Mourning Dove	some overwinter
C. Flicker	some overwinter
Blue Jay	some overwinter
European Starling	some overwinter
House Wren	
Am. Robin	northern subspecies overwinter
Brown Thrasher	
Eastern Towhee	some overwinter
Chipping Sparrow	

Field Sparrow	
Song Sparrow	some overwinter
Red-winged Blackbird	
Common Grackle	
Brown-headed Cowbird	

Stopover Migrants, Spring and Fall

Red-shouldered Hawk	some overwinter
Sharp-shinned Hawk	some overwinter
Broad-winged Hawk	
Cooper's Hawk	
Yellow-bellied Sapsucker	some overwinter
Acadian Flycatcher	
Alder Flycatcher	
Least Flycatcher	
Tree Swallow	
Brown Creeper	
Red-breasted Nuthatch	
Winter Wren	some overwinter
Golden-crowned Kinglet	
Ruby-crowned Kinglet	some overwinter
Gray-cheeked Thrush	
Bicknell Thrush	
Swainson's Thrush	
Hermit Thrush	some overwinter
Philadelphia Vireo	
Blue-headed Vireo	
Yellow-rumped Warbler (Myrtle)	some overwinter
Pine Warbler	
Palm Warbler	
Black-throated Green Warbler	
Black-throated Blue Warbler	
Worm-eating Warbler	
Louisiana Waterthrush	
Northern Waterthrush	
Kentucky Warbler	
Hooded Warbler	
Northern Parula	
Chestnut-sided Warbler	
Prothonotary Warbler	
Canada Warbler	
Prairie Warbler	
Yellow-breasted Chat	
Tennesee Warbler	
Mourning Warbler	
Connecticut Warbler	
Nashville Warbler	
Magnolia Warbler	
Blackpoll Warbler	
Blackburnian Warbler	
Orchard Oriole	

Lincoln's Sparrow
Swamp Sparrow
White-throated Sparrow
Slate-colored Junco
Purple Finch
American Tree Sparrow

APPENDIX 5 – Amphibians and Reptiles

Spotted Salamander	*Ambystoma maculatum*
Red-backed Salamander (red & gray phases)	*Plethodon cinereus*
Slimy Salamander	*Plethodon glutinosus*
Northern Two-lined Salamander	
Northern Red Salamander	
Northern Dusky Salamander	
Jefferson Salamander	
American Toad	
Fowler's Toad	*Bufo fowleri*
Spring Peeper	*Hyla crucifer*
Bullfrog	*Rana catesbeiana*
Green Frog	*Rana clamitans*
Wood Frog	*Rana sylvatica*
Pickerel Frog	*Rana palustris*
Northern Gray Tree Frog	*Hyla versicolor*
Common Musk Turtle	
Spotted Turtle	*Clemmys guttata*
Box Turtle	*Terrapene carolina*
Eastern Painted Turtle	*Chrysemys marginata*
Snapping Turtle	*Chelydra serpentina*
Black Rat Snake	
Common Garter Snake	*Thammophis sirtalis*
Ribbon Snake	*Thamnophis sauritus*
Ringneck Snake	
Black Racer	*Coluber constrictor*
Milk Snake	*Lampropeltis triangulum*
Northern Water Snake	*Natrix sipedon*

APPENDIX 6 – Mammals

Big Brown Bat	*Epesicus fuscus*
Little Brown Myotis	*Myotis lucifugus*
House Mouse	*Mus Muscus*
White-footed Mouse	*Peromyscus leocopus*
Meadow Vole	*Microtus pennsylvanicus*
Eastern Chipmunk	*Tamias striatus*
Red Squirrel	*Tamiasciurus hudsonicus*
Gray Squirrel	*Scirus carolinensis*
Eastern Cottontail	*Sylvilagus floridanus*
Woodchuck	*Marmota monax*
Eastern Mole	*Scalopus aquaticus*
Star-nosed Mole	*Condylura cristata*
Opossum	*Didelphis marsupialis*
Raccoon	*Procyon lotor*
Striped Skunk	*Mephitis mephitis*
Long-tailed Weasel	*Mustela frenata*
White-tailed Deer	*Odocoileus virginianus*
Red Fox	*Vulpes fulva*

APPENDIX 7 – Plants

OBLW	Obligate wetland species
FACW	Facultative wetland species
FACU	Facultative upland species
FAC	Likely to occur
*	Imported
**	Protected

APRIL

Northern White Violet	*Viola pallens*	OBLW
Common Winter Cress	*Brassica rapa*	
Common Blue Violet	*Viola papilionacea*	FAC
Round-leafed Yellow Violet	*Viola rotundifolia*	FAC+
Spring Beauty	*Claytonia virginica*	FACU
May Apple	*Podophyllum peltatum*	FACU
Coltsfoot*	*Tussilago farfara*	
Common Strawberry	*Fragaria virginiana*	FACU
Common Cinquefoil	*Potentilla simplex*	FACU-
Wild Geranium	*Geranium maculatum*	FACU
Cut-leaf Toothwort	*Dentaria laciniata*	
Small Jack-in-the pulpit	*Arisaema triphyllum*	
Jack-in-the-pulpit	*Arisaema atrorubens*	
Blood Root**	*Sanguinaria canadensis*	
Trout-lily	*Erythronium americanuum*	
Wild Leek	*Allium tricoccum*	FACU+
Field Garlic	*Allium vineale*	FACU-
Skunk Cabbage	*Symplocarpus faetidus*	OBLW
Speedwell, American	*Veronica Americana*	OBLW
Rue Anemone	*Anemonella thalictroides*	
Dandelion	*Taraxacum officinale*	
Buttercup	*Ranunculus species*	some OBLW
Virginia Waterleaf	*Hydrophyllum virginianum*	
Smaller Forget-me-not	*Myosotis laxa*	
Yellow Stargrass	*Hypoxis hirsuta*	
Japanese Silverberry*	*Eleagnus umbellata*	

MAY

Poison-ivy	*Rhus radicans*	
Virginia Creeper	*Parthenocissus quinquefolia*	FACU
Partridge Berry	*Mitchella repens*	FACU
Common Highbush Blueberry	*Vaccinium croymbosum*	FACW-
Common Lowbush Blueberry	*Vaccinium angustifolium*	FACU-
Common Ragwort	*Senecio obovatus*	FACU-
Common Groundsel	*Senecio vulgaris*	FACU
Multiflora Rose	*Rosa multiflora*	

Common Blackberry (Highbush)	*Rubus allegheniensis*	FACU-
Commom Dewberry	*Rubus flagellaris*	
Black Raspberry	*Rubus occidentalis*	
Wine Raspberry*	*Rubus phoenicolasius*	
Fox Grape	*Vitis species labrusca*	FACU
Summer Grape	*Vitis species aestivalis*	FACU
Frost Grape	*Vitis species vulpina*	
New England Grape	*Vitis species novae-angliae*	
Japanese Honeysuckle*	*Lonicera japonica*	
Wild Rose	*Rosa carolina*	UPL
Common Greenbriar**	*Smilas rotundifolia*	FAC
Poison Ivy	*Rhus radicans*	
Northern Bayberry	*Myrica pensylvanicum*	FAC
Common Milkweed	*Asclepias syriaca*	
Broad Leafed Milkweed	*Asclepias amplexicaulis*	
Swamp Milkweed	*Asclepias incarnata*	OBLW
Devil's Paintbrush	*Hieracium aurantiacum*	
Jewelweed (Spotted Touch-me-not)	*Impatiens capensis*	FACW
Hairy Beardtongue	*Penstemon hirsutus*	
Common Chick Weed	*Stellaria media*	
White Campion	*Lychnis alba*	
Ground Ivy	*Glechoma hederacea*	FACU
Purple Milkwort	*Polygala species*	FACW
Moth Mullein	*Verbascum thapsus*	
Field Pennycress*	*Thlapsi arbvense*	
Golden Ragwort	*Senecio aureus*	
Garlic Mustard	*Alliaria petiolata*	

JUNE

Field Daisy	*Chrysanthemum leucanthemum*	
Field Hawkweed	*Hieracium pratense*	
Daisy Fleabane	*Erigeron annuus*	FACU
Whorled Loosestrife	*Lysimachia quadrifolia*	FACU-
Two-flowered Cynthia	*Krigia biflora*	FACU
Bouncing Bet*	*Saponaria officinalis*	
Sundrop	*Oenothera fruticosa*	FACU-
Black-eyed Susan	*Rudbeckia hirta*	FACU-
Sow Thistle*	*Sonchus species*	
Canada Thistle*	*Circium arvense*	
American Elderberry	*Sambucus canadensis*	FACW-
Cow Vetch*	*Vicia cracca*	
Wild Pea	*Lathyrus palustris*	FACW+
Dayflower	*Commelina species*	FACW
Cow Parsnip	*Heracleum maximum*	
Sasaparilla**	*Aralia nudicalis*	FACU
Sheep Sorrel*	*Rumex acetosella*	

White Clover	*Melilotus alba*	FACU
Red Clover*	*Trifolium pratense*	
Yellow Sweet Clover*	*Melilotus officinalis*	FACU-
Hop (Yellow Clover)*	*Trifolium agrarium*	
Tick Trefoil	*Desmodium canadense*	FAC
Blue Vervain	*Verbena hastata*	FACW+
Common St. Johnswort*	*Hypericum perforatum*	
Cardinal Flower**	*Lobelia cardinalis*	FACW+
Spiked Lobelia	*Lobelia spicata*	
Wild Pink	*Silene caroliniana*	
Long-leafed Stitchwort	*Stellaria longifolia*	
Wild Balsam Apple	*Echinocystis Lobata*	
Eastern Blue-eyed Grass	*Sisyrinchium atlanticum*	FACW
Stout Blue-eyed Grass	*Sisyrinchium angustifolium*	
Common Blue-eyed Grass	*Sisyrinchium montanum*	
Yellow Stargrass	*Hypoxis hirsuta*	
Horse Nettle	*Solanum carolininse*	
Fringed Loosestrife	*Lysimachia ciliata*	
Common Plantain	*Plantago major*	
Black Cohosh	*Cimicifuga racemosa*	
JULY		
Yarrow*	*Achillea millefolium*	FACU
Purple Milkweed	*Asclepias purpurescens*	OBLW
Tall Meadow Rue	*Thalictrum polygamum*	
White Avens	*Geum canadense*	
Indian Hemp (Clasping-leaf Dogbane)	*Apocynum cannabinum*	FACU
Early Goldenrod	*Solidago juncea*	
Birdfoot Trefoil	*Lotus corniculatus*	FACU-
Narrow-leafed Mountain Mint	*Pycanthemum tenuifolium*	FACW
Yellow Bedstraw	*Galium verum*	
Hounds Tongue Forget-me-not	*Cynoglossum officinale*	
Galinsoga (Quickweed)	*Galinsoga ciliata*	
Virginia Knotweed	*Tovara virginiana*	
Raggid Fringed Orchis	*Habenaria lacera*	
Wild Basil	*Satureja vulgaris*	
AUGUST		
Pickerelweed	*Pontedaria cordata*	OBLW
Slender Gerardia	*Agalinis tenuifolia*	FACU
Queen Ann's Lace	*Daucus carota*	FACU
Boneset	*Eupatorium perfoliatum*	FACW+
Bur Marigold	*Bidens laevis*	OBLW
Heal-all*	*Prunella vulgaris*	
Bull Thistle	*Cirsium vulgare*	
New York Aster	*Aster novae-belgii*	FACW+

New England Aster	*Aster novae-angliae*	FACW-
Small White Aster	*Aster vivineus*	FACW
Arrow-leafed Tearthumb	*Polygonum sagittatum*	OBLW
Long-bristled Smartweed	*Polygonum cespitosum*	
Rough-stemmed Goldenrod	*Solidago rugosa*	FAC
Grass-leafed Goldenrod	*Euthamia graminifolia*	FACW
Field Thistle	*Cirsium discolor*	
Pilewort	*Erectites hieracifolia*	FACU
Pokeweed	*Phytolacca americana*	FACU+
New York Ironweed	*Vernonia noveboracensis*	FACW+
Common Ragweed	*Ambrosia artemisiifolia*	FACU
Joe-pye-weed	*Eupatoriadelphus dubius*	FACW
Hyssop Skullcap	*Scutellaria integrifolia*	
Agrimony	*Agrimony spp.*	
Purple Milkwort	*Polygala sanguiena*	
Indian Tobacco	*Lobelia inflata*	
SEPTEMBER		
Heart-leafed Aster	*Aster cordifolius*	
Lawrie's Aster	*Aster lowrieanus*	
Slender Gerardia	*Agalinis tenuifolia*	
White Wood Aster	*Aster divaricatus*	
Panicled Aster	*Aster simplex*	FACW
Heath Aster	*Aster ericoides*	FACU
Bushy Aster	*Aster dumosus*	FAC
Pennsylvania Smartweed	*Polygonum pensylvanicum*	FACW
Cocklebur	*Xanthium pensylvanicum*	FAC
Common Burdock*	*Arctium minus*	
Giant Goldenrod	*Solidago gigantea*	FACW
Beechdrops	*Epifagus virginiana*	

FERNS AND ALLIES

New York Fern	*Thelypteris noveboracensis*	
Sensitive Fern	*Onoclea sensibilius*	FACW
Christmas Fern	*Polystichum acrostichoides*	FACU
Lady Fern	*Athyrium Felix-femina*	FAC
Cut-leaved Grape Fern	*Botrychium dissectum Spreng.*	
Hay-scented Fern	*Dennstaedia punctilobula*	
Common Polypody	*Polypodium virginianum*	
Ground Pine/Running Pine	*Lycopodium tristachyjm (clavatum)*	FAC
Moss	*Pollytrichum* sp.	
Moss	*Atricum* sp.	

MUSHROOMS, LICHENS

British Soldiers	*Cladonia cristatella*
Stalked Scarlet Cup	*Sarcoscypha occidentalis*
Bird's Nest Fungi	*Cyathus striatus*
Bird's Nest Fungi	*Crucibulum laeve*
Witches' Jelly	*Tremella* sp
Common Scleroderma	*Scleroderma* sp.

SEDGES AND RUSHES

Trianglestem Spikerush	*Eleocharis robbinsii*	OBLW
Four Square	*Eleocharis species*	OBLW
Spike Rush	*Eleocharis species*	OBLW
Wool Grass	*Scirpus cyperinus*	
Dark Green Bulrush	*Scirpus atrovirens*	
Path Rush	*Scirpus tenuis*	
Umbrella Sedge	*Cyperus strigosus*	
Twig Rush	*Scirpus species*	
Tussock Sedge	*Carex stricta*	
Wooly Sedge	*Carex lanuginosa*	OBLW
Sedge, one of the ovales	*Carex scoparia*	
Sedge	*Carex intumescens*	
Bottle Brush Sedge	*Carex lurida*	
Sedge	*Carex Lupulina*	
Soft Rush	*Juncus effusus*	
Rush	*Juncus canadensis*	
Cattail	*Typha latifolia*	OBLW

GRASSES

Orchard Grass*	*Dactylis glomerata*	
Red-topped Grass	*Agrostis alba*	FACW
Meadow Foxtail Grass	*Alopecurus geniculatus*	OBLW
Bristly Foxtail	*Setaria*	

Switch Grass	*Panicum virgatum*
Deer-tongue Grass	*Panicum clandestinum*
Panic Grass	*Panicum lanuginosum*
Reed Canary Grass*	*Phalaris arundinacea*
Tall Oats Grass	*Arrhenatherum elatius*
Brome Grass*	*Bromus ciliatus*
Little Bluestem	*Andropogon scoparius*
Sweet Vernal Grass	*Antheroxanthum odoratum*
Quack Grass	*Agropyron repens*
Indian Grass	*Sorghastrum nutans*
Wirestem Muhly	*Muhlenbergia frondosa*
Meadow Fescue	*Festuca elatior*
Red Fescue	*Festuca rubra*
Stilt Grass*	*Microstegium vimineum*
Barnyard Grass*	*Echinochloa crusgalli*

SHRUBS

Panicled Dogwood	*Cornus foemina ssp. racemosa*	FACW+
Silky Dogwood	*Cornus amomum*	
Northern Spicebush	*Lindera benzoin*	FACW-
Steeple Bush	*Spirea tomentosa*	FACW
Northern Bayberry	*Myrica pensylvanicum*	FAC
Arrowwood	*Viburnum dentatum*	
Shadbush	*Amelanchier arborea*	
Nannyberry	*Viburnum lentago*	FAC
Japanese Silverberry, Autumn Elaeagnus	*Elaeagnus umbellata*	
Winged Euonymus	*Euonymus alata*	
Staghorn Sumac	*Rhus typhina*	
Red Chokeberry	*Pyrus arbutifolia*	
Winterberry	*Ilex verticillata*	
Privit	*Ligustrum vulgare*	
Japanese Barberry	*Berberis thunbergii*	
Amur Honeysuckle	*Lonicera Maackii*	
Morrow Honeysuckle	*Lonicera morrowi*	

TREES

Red Maple	*Acer rubrum*	FAC
Sugar Maple	*Acer saccharum*	
Silver Maple	*Acer saccharinum*	FACW
Crab Apple	*Pyrus species*	
Gray Birch	*Betula populifolia*	
Black Birch	*Betula lenta*	
Flowering Dogwood	*Cornus florida*	
Eastern Red Cedar	*Juniperus virginiana*	
Red Mulberry	*Morus rubra*	FACU
Slippery Elm	*Ulmus rubra*	FAC
Osage Orange	*Maclura pomifera*	
Staghorn Sumac	*Rhus typhina*	
Swamp White Oak	*Quercus bicolor*	FACW+
White Oak	*Quercus alba*	
Pin Oak	*Quercus paulistris*	FACW
Swamp Chestnut Oak	*Quercus michauxii*	FACW
Black Oak/Red Oak	*Quercus species*	
Basswood	*Tilia americana*	
Tuliptree	*Liriodendron tulipifera*	
White Ash	*Fraxinus americana*	
Shagbark Hickory	*Carya ovata*	
Mockernut Hickory	*Carya tomentosa*	
Black Walnut	*Juglans nigra*	

Sassafras	*Sassafras albidum*
Ironwood	*Carpinus caroliniana*
Sycamore	*Platanus occidentalis*
American Beech	*Fagus grandifolia*
Persimmon	*Diospyros virginiana*
Common Catalpa	*Catalpa bignonioides*

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[ii] "Geology of the Newark Rift Basin", Roy Schlische, Department of Geological Sciences, Rutgers University.

[iii] "Surface Water Quality Standards", N.J.A.C. 7:9B, New Jersey Department of Environmental Protection, pg. 4.
[iv] Ibid, pgs. 2-3
[v] Ibid, pg. 3
[vi] "Bedrock Geology and Topographic Base Maps of New Jersey", New Jersey Geological Survey CD Series CD 00-1, New Jersey Geological Survey, 2001.

[vii] "Building Greener Communities – Planning for Woodland Conservation (Appendix D", Marybeth H. Carter, ASLA, AICP, June 2003.

Figure 1

Level I Classification 1995 Land Use/ Land Cover

The Sourland Mountain

A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

- AGRICULTURE
- BARREN LAND
- FOREST
- URBAN
- WATER
- WETLANDS

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
1995 Land Use/Land Cover Edition 1.3 - WMA 10 (Millstone Watershed Management Area), Originator - NJDEP, OIRM, BGIA, Source Scale 1:12,000.

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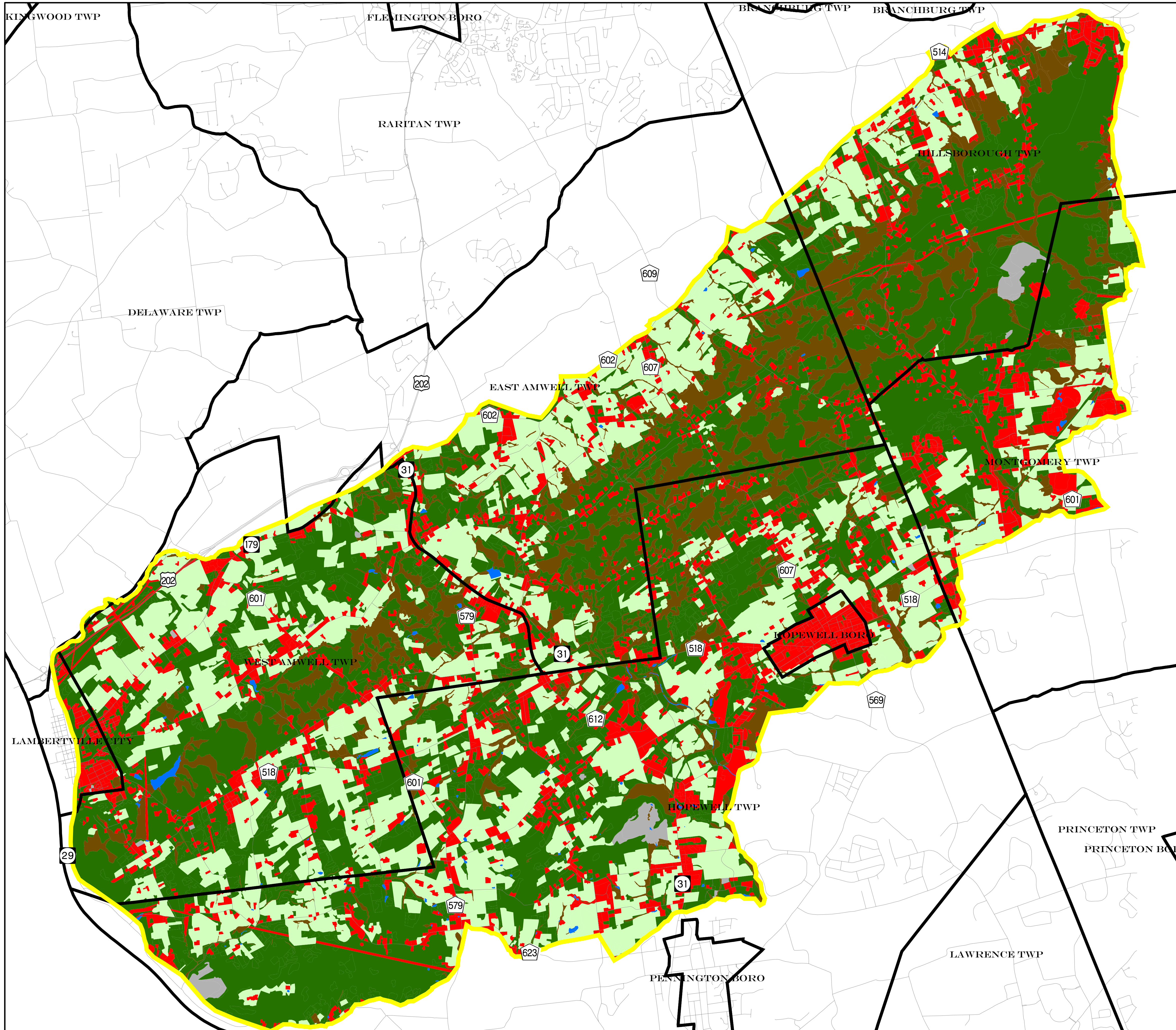

Figure 2

1995 Land Use/ Land Cover

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

- Agricultural Land
- Agricultural Wetlands
- Other Agriculture
- Brush Covered Field
- Altered Lands
- Commercial
- Industrial
- Brush/Shrubland
- Coniferous Forest
- Deciduous Forest
- Mixed Forest
- Coniferous Wooded Wetlands
- Deciduous Wooded Wetlands
- Mixed Wooded Wetlands
- Disturbed Wetlands
- Managed Wetland
- Exposed Rock
- Mining
- Other Urban
- Recreational Land
- Residential
- Residential, High Density
- Transitional Areas
- Transportation and Utilities
- Water
- Wetlands

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1995 Land Use/Land Cover Edition 1.3 - WMA 10 (Millstone Watershed Management Area), Originator - NJDEP, OIRM, BGIA, Source Scale 1:12,000.

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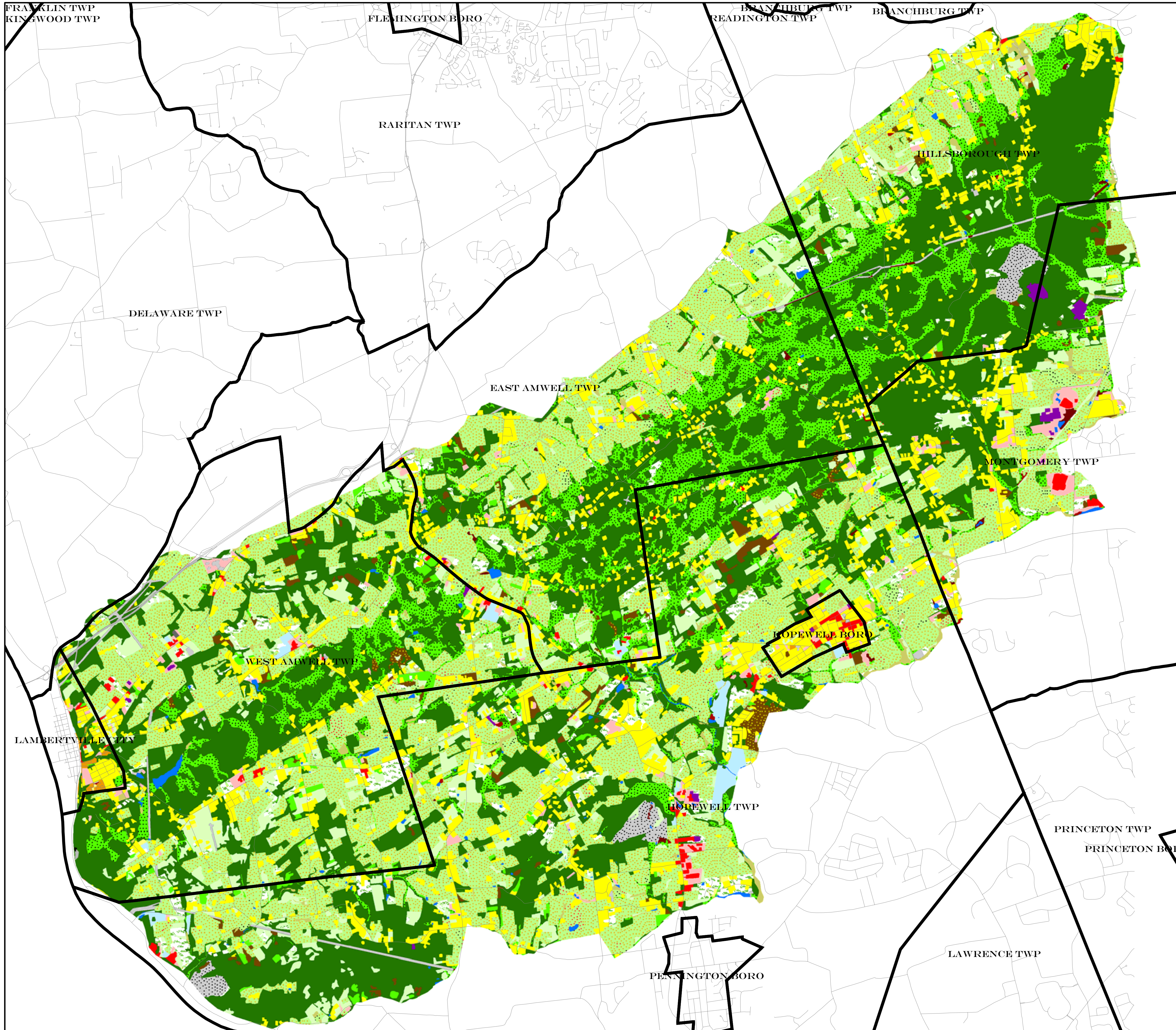

Figure 3
Land Use/Land Cover Comparison
1972, 1986 and 1995

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 3 4 Miles

Legend

- Agriculture
- Barren Land
- Forest
- Urban
- Water
- Wetlands

Data Sources 1972:
New Jersey 1972 Level ILand Cover Classification,
Originator - Grant F. Walton Center for Remote
Sensing and Spatial Analysis Rutgers University,
Source Data Resolution - 80 meters x 80 meters.

Data Sources 1986:
1986 Land Use/Land Cover for Somerset County,
New Jersey, Originator - NJDEP, OIRM, BGIA,
Source Scale 1:24,000.

Data Sources 1995:
New Jersey 1995 Level ILand Cover Classification,
Originator - Grant F. Walton Center for Remote
Sensing and Spatial Analysis Rutgers University,
Source Data Resolution - 80 meters x 80 meters.

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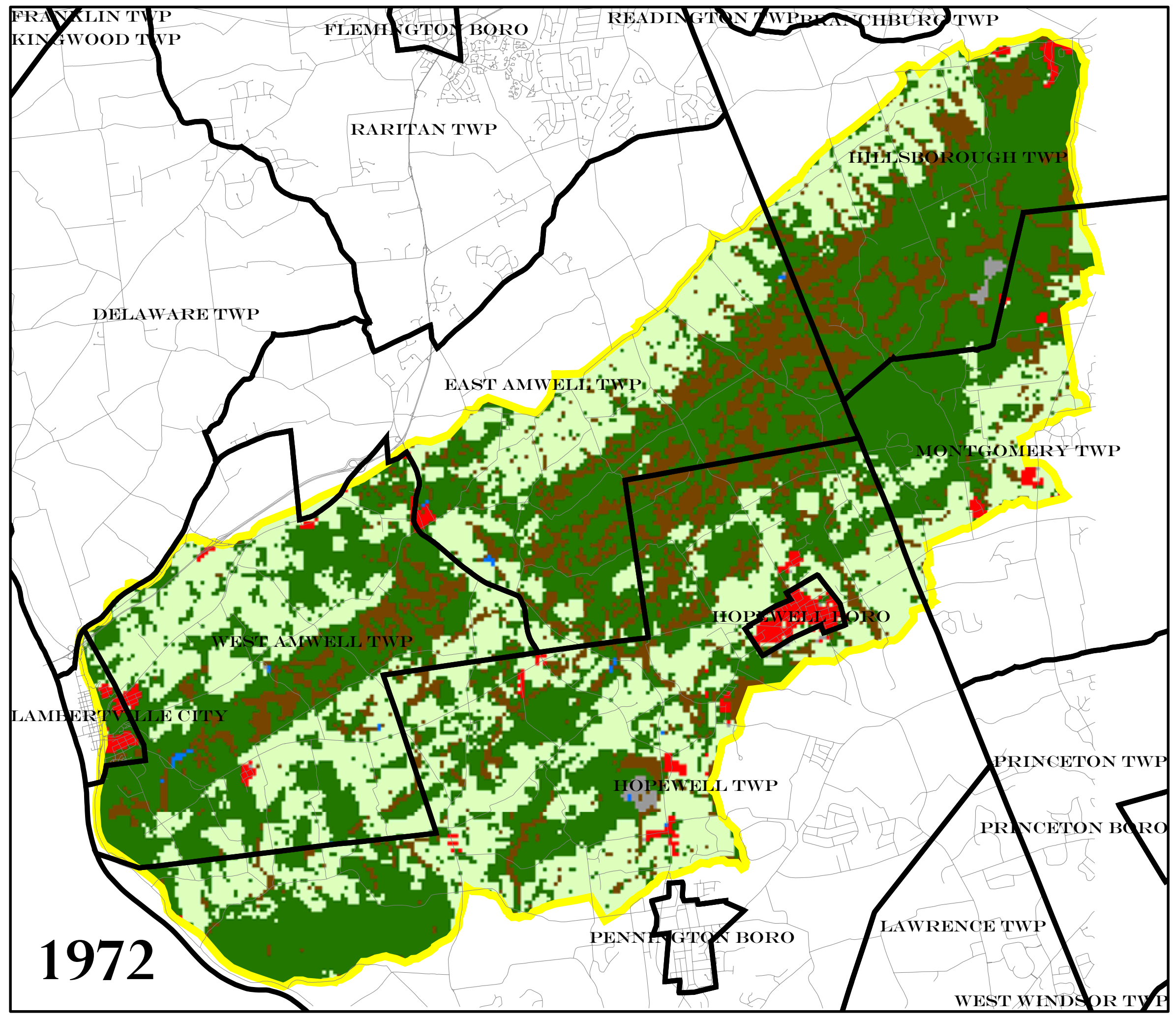

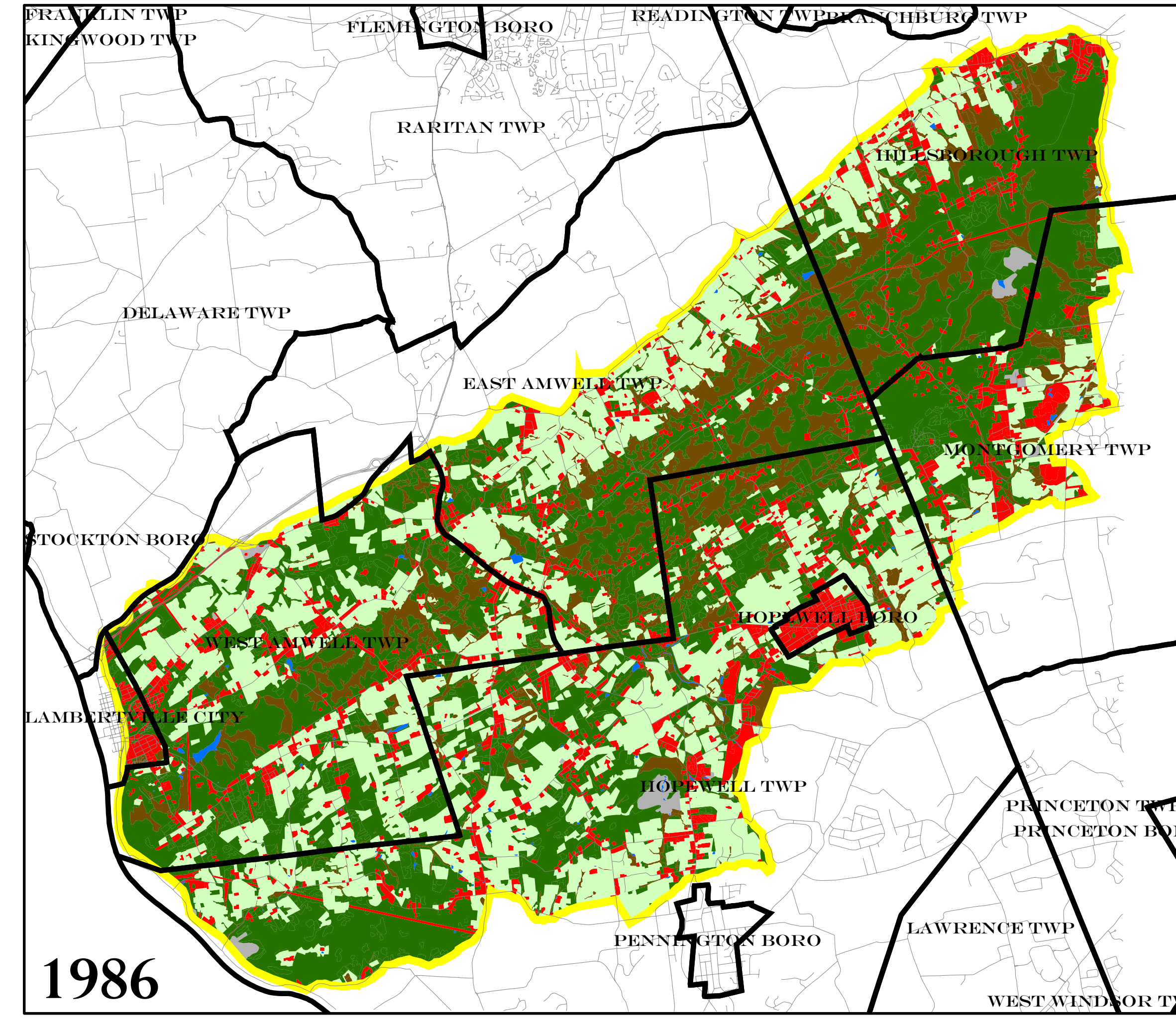

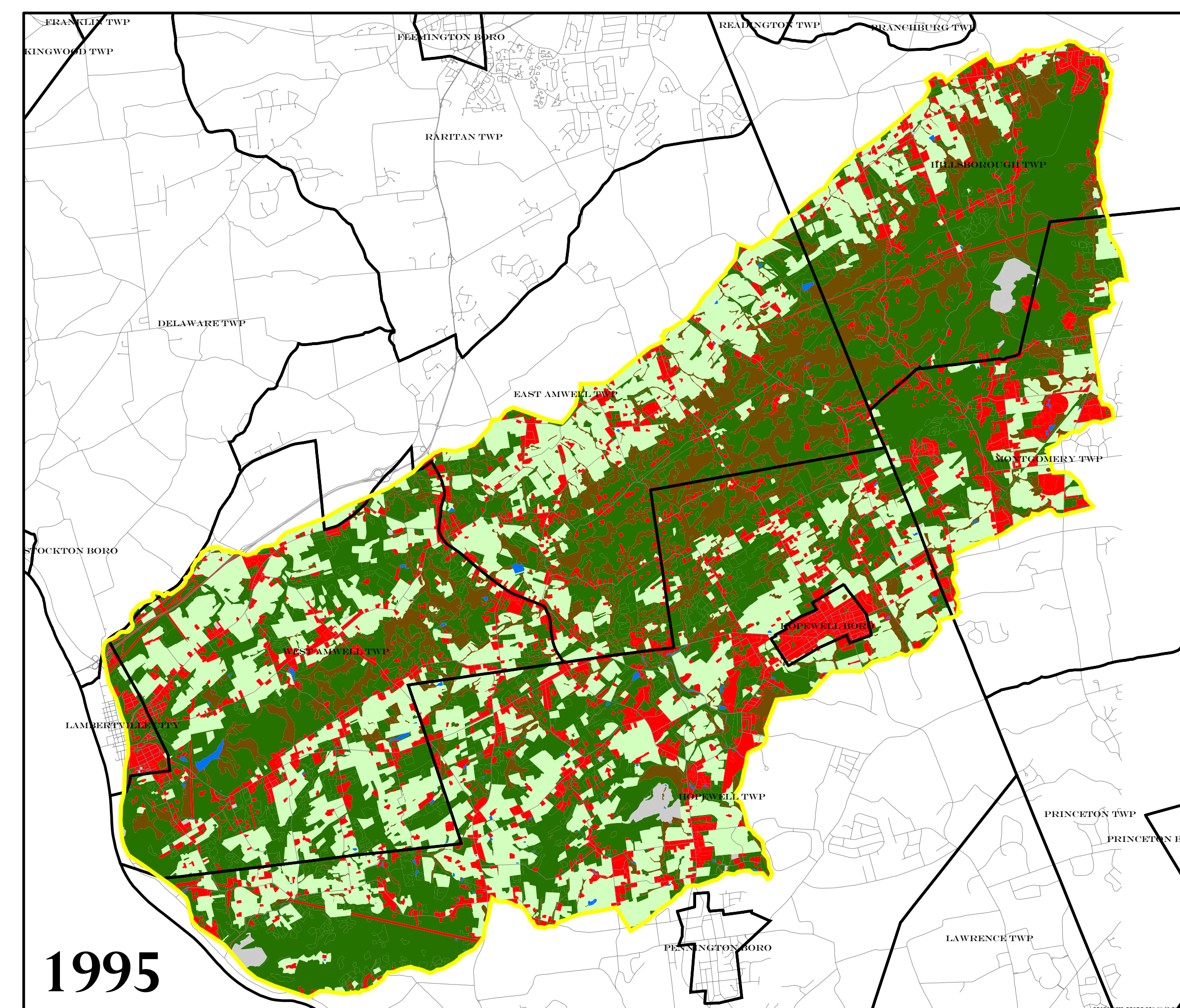

Figure 4

1995 Forested Areas and Forested Area Change

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

- New Forest Areas Since 1986
- Forested Areas Converted to Other Uses
- Brush Covered Field
- Brush/Shrubland
- Coniferous Forest
- Deciduous Forest
- Mixed Forest
- Coniferous Wooded Wetlands
- Deciduous Wooded Wetlands
- Mixed Wooded Wetlands

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Data Sources:
1995 Land Use/Land Cover Edition 1.3 - WMA 10 (Millstone Watershed Management Area), Originator - NJDEP, OIRM, BGIA, Source Scale 1:12,000.

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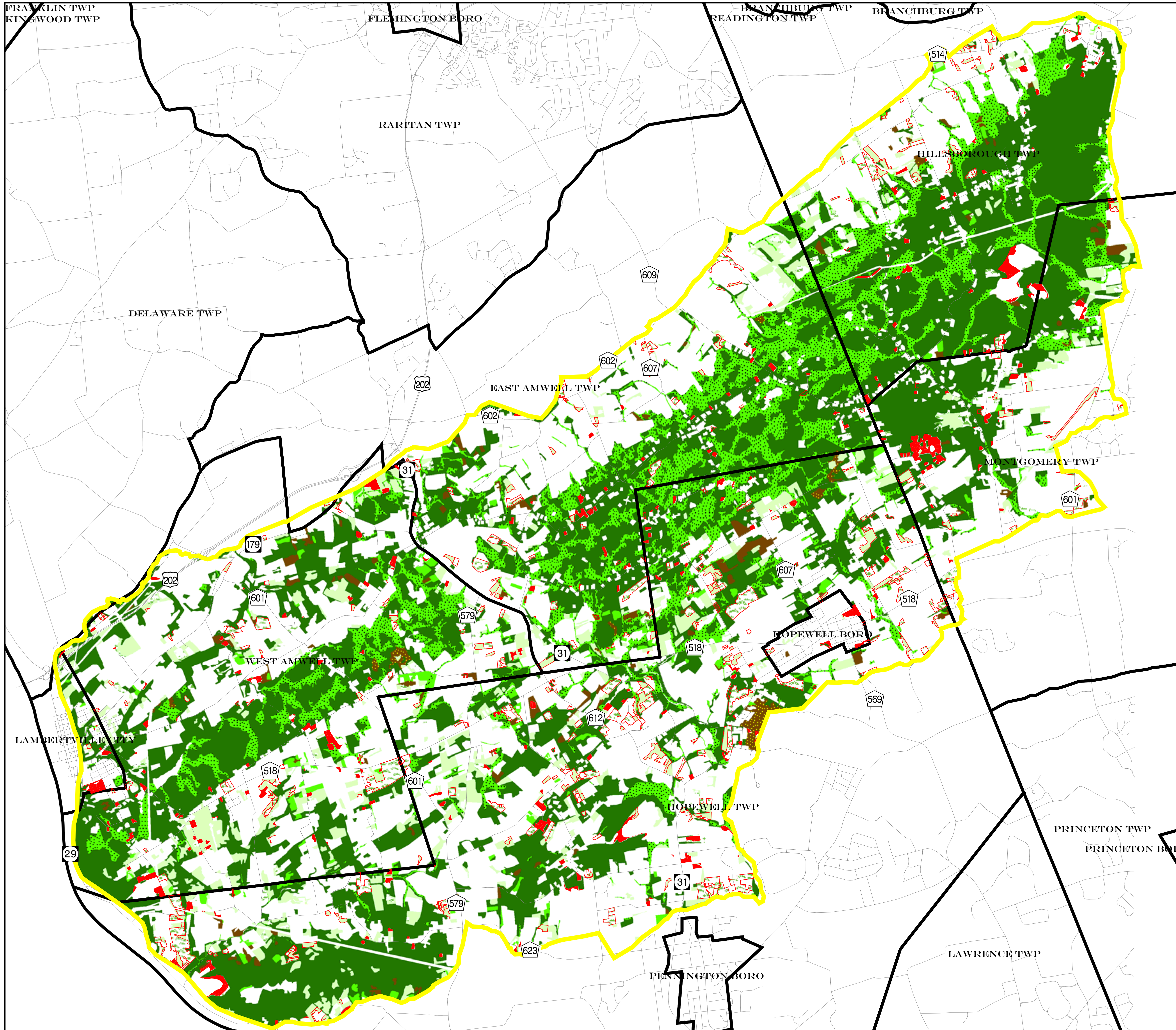

Figure 5
Forest Patch 1
East of State Route 31

The Sourland Mountain Region
A Portion of Central New Jersey

0 0.5 1 Miles

Legend

- Brush Covered Field
- Brush/Shrubland
- Coniferous Forest
- Deciduous Forest
- Mixed Forest
- Coniferous Wooded Wetlands
- Deciduous Wooded Wetlands
- Mixed Wooded Wetlands

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A S S O C I A T E S, I N C.
Planning and Design

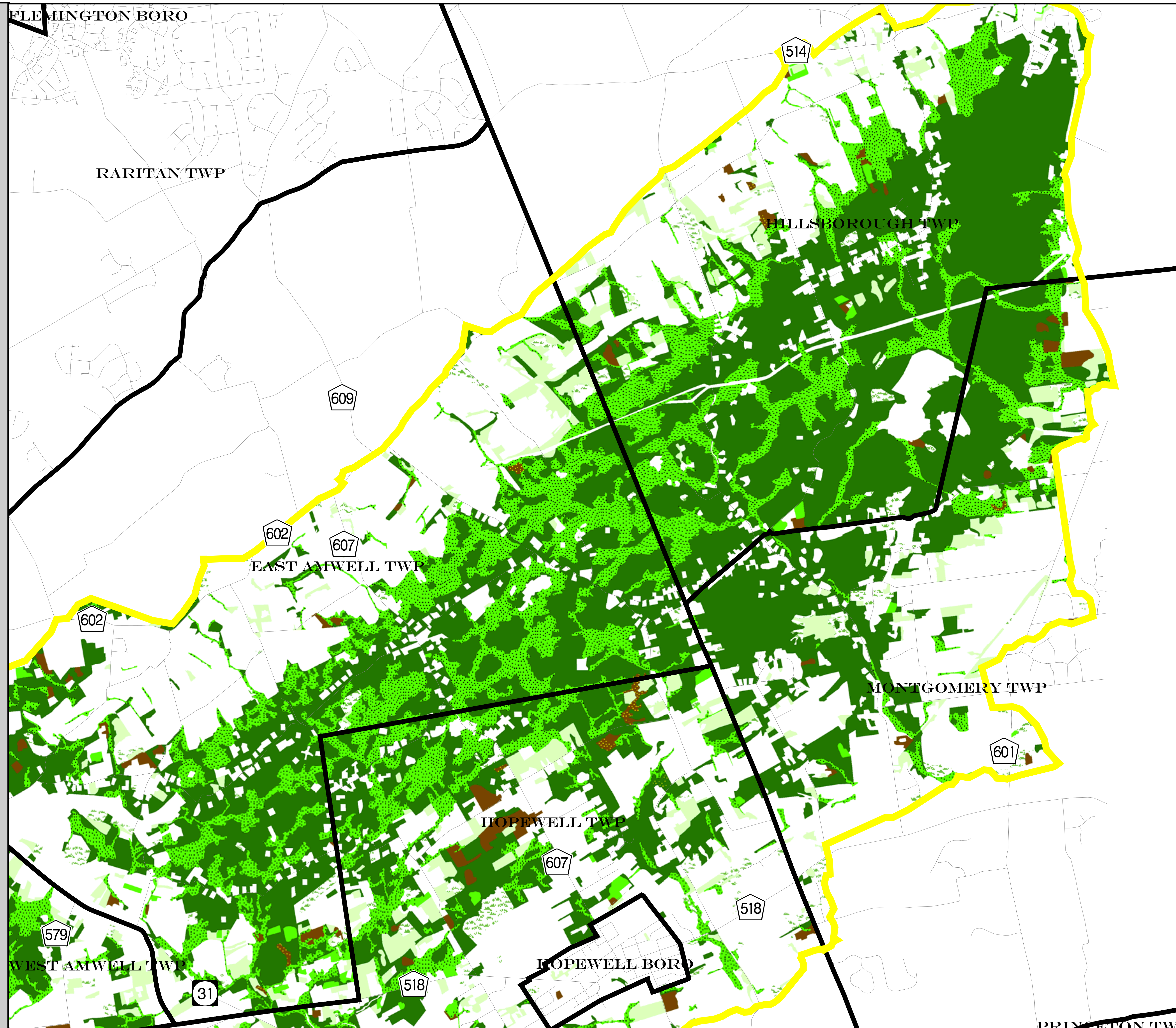

Figure 6
Forested Areas of Central New Jersey

The Sourland Mountain Region
A Portion of Central New Jersey

0 0.5 1 2 3 4 5
Miles

Legend

Forested Areas

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
1995 Land Use/Land Cover Edition 1.3 - WMA 10 (Millstone Watershed Management Area), Originator - NJDEP, OIRM, BGIA, Source Scale 1:12,000.

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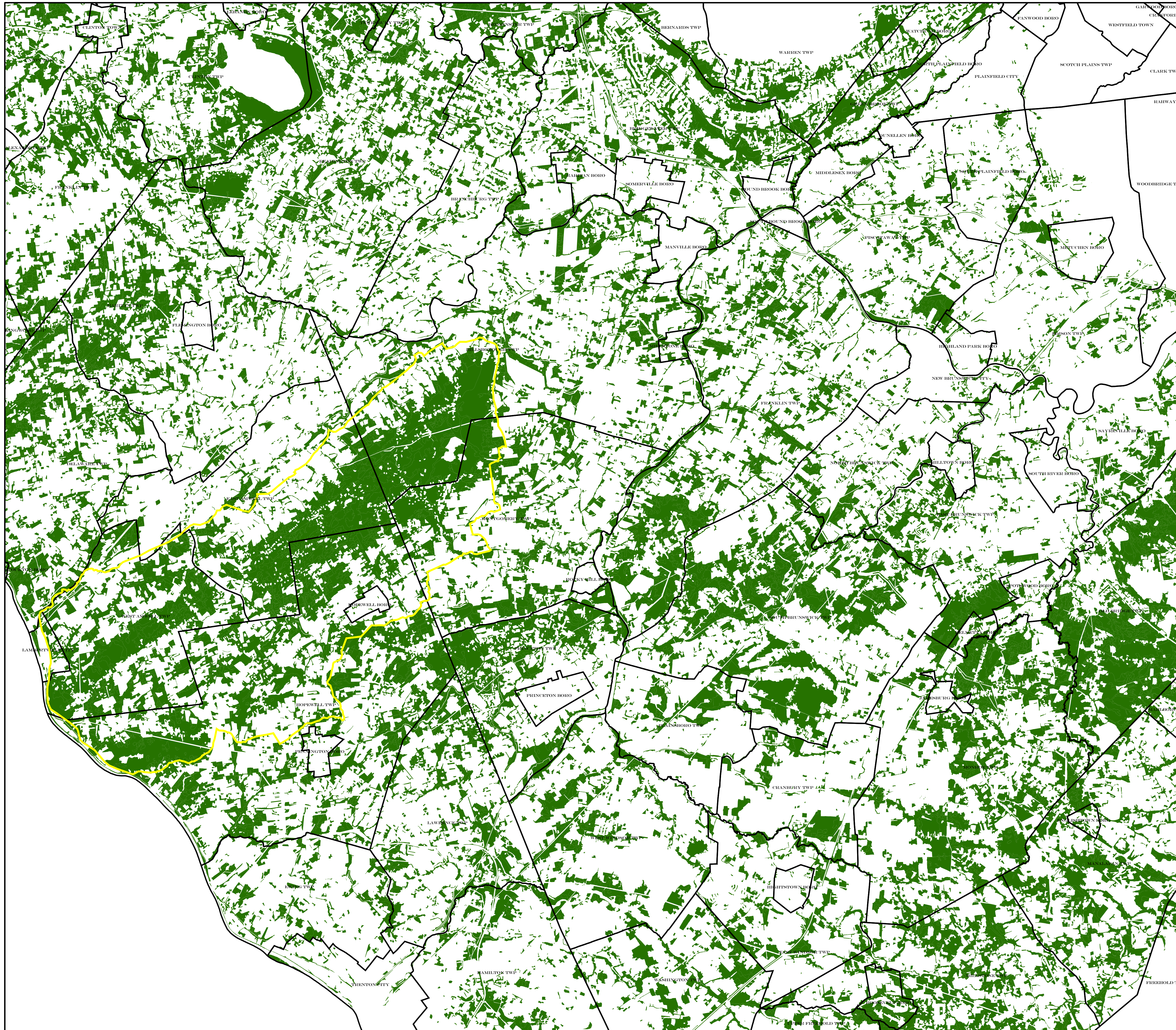
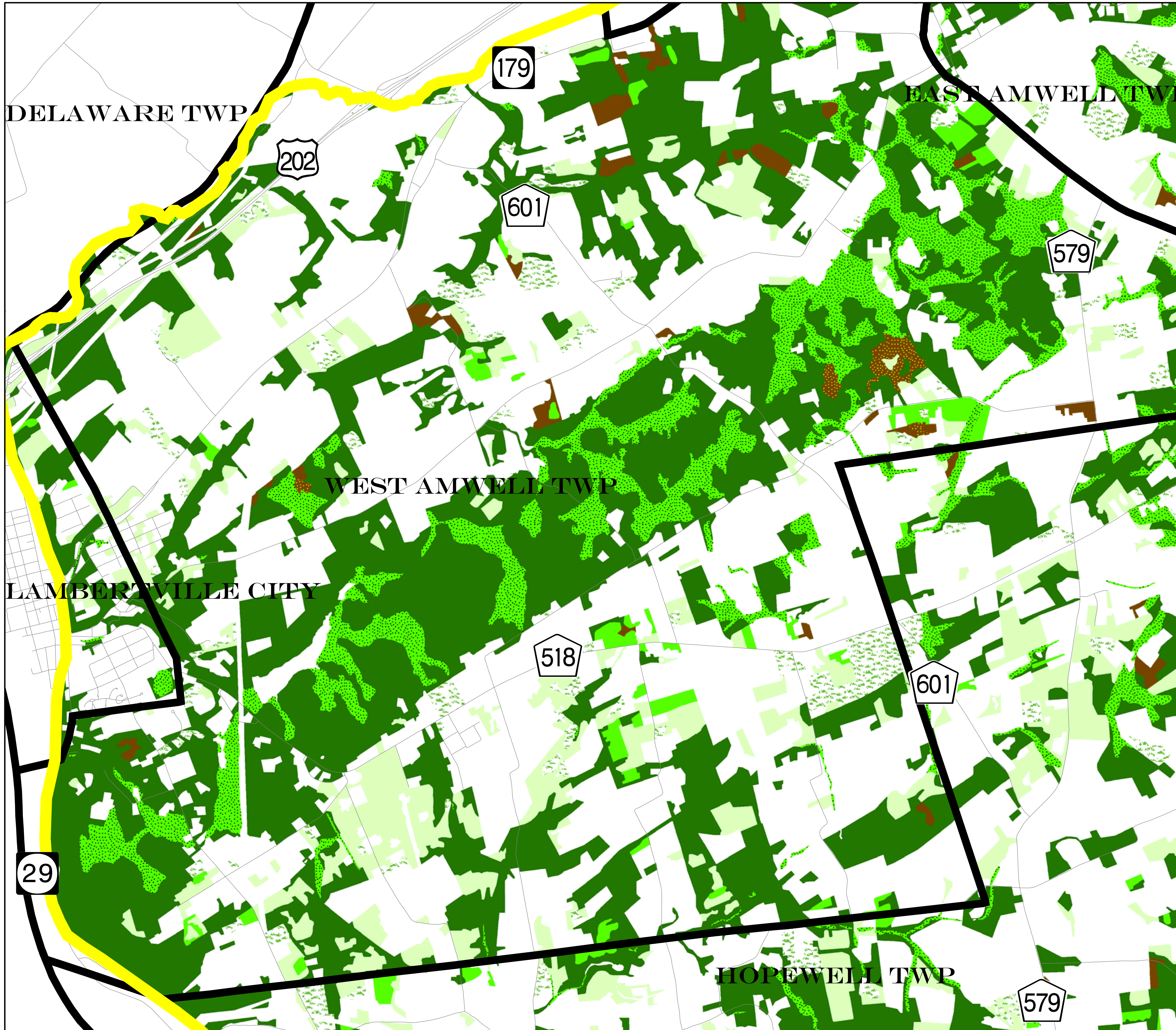


Figure 7
Forest Patch 2
West of State Route 31

The Sourland Mountain Region
A Portion of Central New Jersey



0 0.5 1 Miles

Legend

- Brush Covered Field
- Brush/Shrubland
- Coniferous Forest
- Deciduous Forest
- Mixed Forest
- Coniferous Wooded Wetlands
- Deciduous Wooded Wetlands
- Mixed Wooded Wetlands

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
1995 Land Use/Land Cover Edition 1.3 - WMA 10 (Millstone Watershed Management Area), Originator - NJDEP, OIRM, BGIA, Source Scale 1:12,000.

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Figure 8

1995 Existing Agriculture and Agricultural Change

The Sourland Mountain Region
A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

New Agriculture Since 1986
Agricultural Land
Other Agriculture
Agriculture Converted to Other Use Since 1986

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
1995 Land Use/Land Cover Edition 1.3 - WMA 10 (Millstone Watershed Management Area), Originator - NJDEP, OIRM, BGIA, Source Scale 1:12,000.

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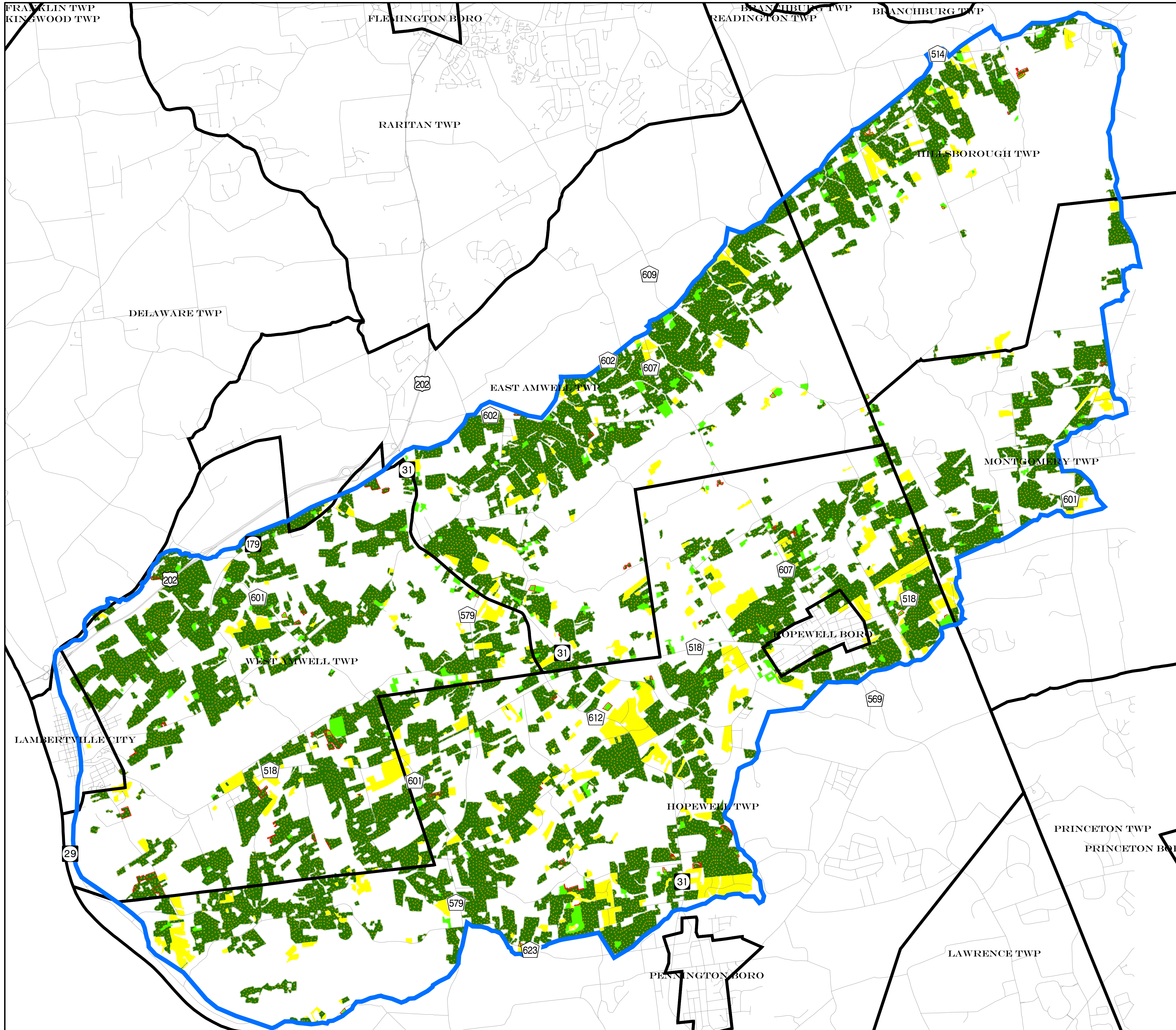


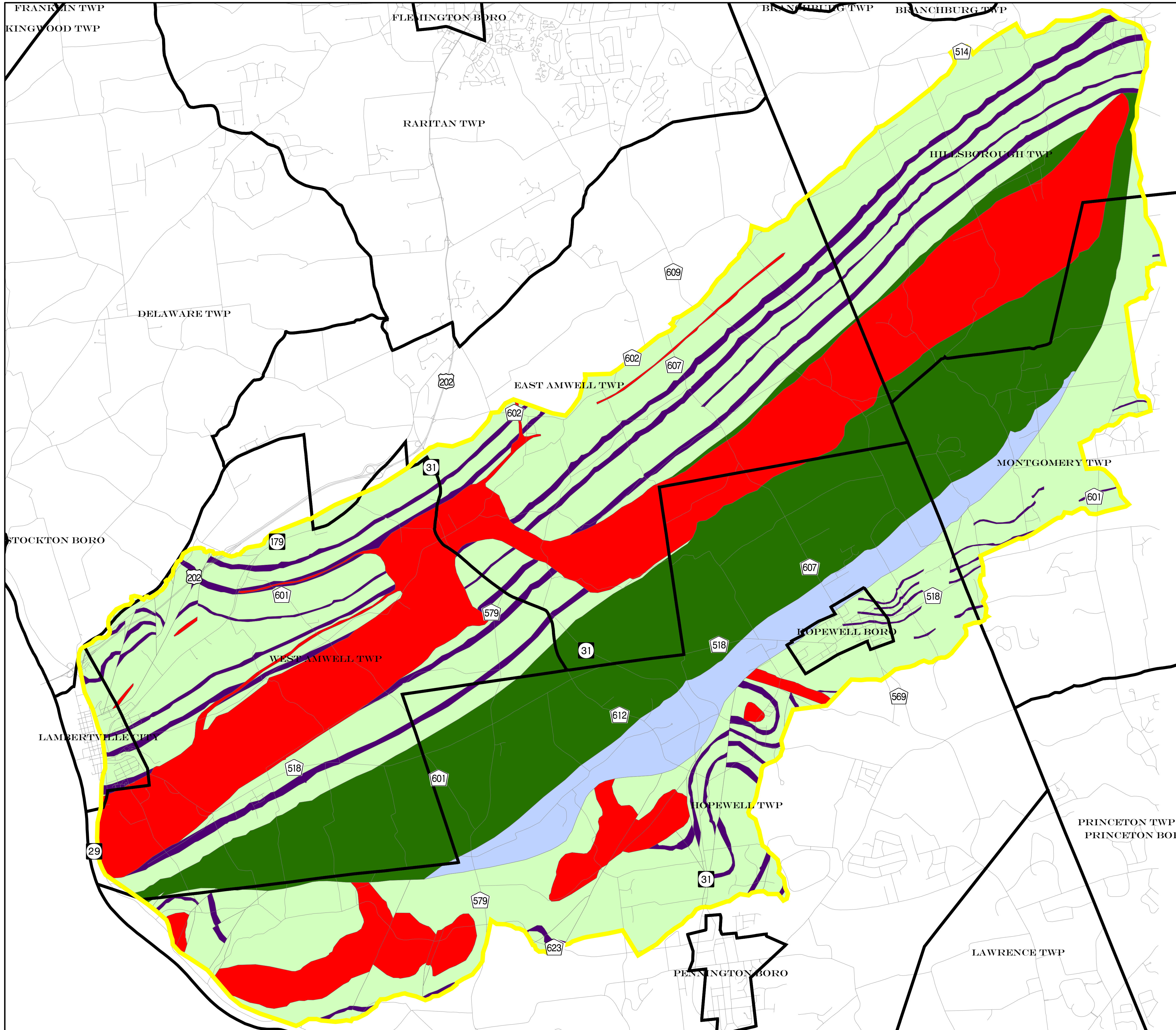
Figure 9

Bedrock Geology

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 Miles



Legend

- Jurassic Diabase
- Lockatong Formation
- Passaic Formation
- Passaic Formation Gray bed
- Stockton Formation

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
"Bedrock Geology and Topographic Base Maps of NJ",
CD Series CD 00-1, Originator - New Jersey Geological Survey,
Source Data Scale - 1:100,000

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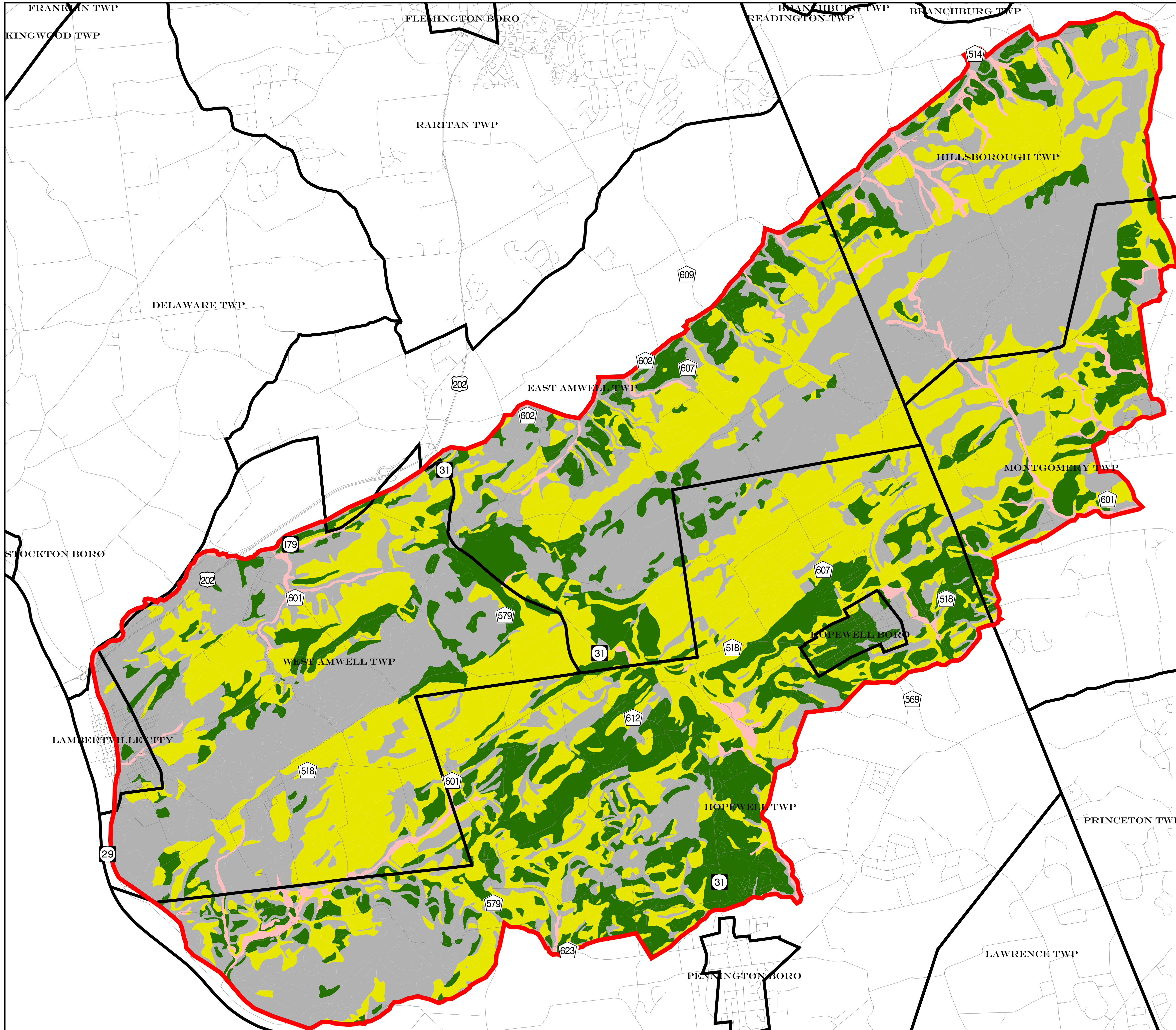
Figure 10
Agriculturally Significant Soils
The Sourland Mountain Region
A Portion of Central New Jersey

0 0.5 1 2 Miles



Legend

- Prime Soil
- Statewide Important Soil
- Farmland of Local Importance
- No Class

Data Sources:
Soil Survey Database for Somerset County, Originator - U.S. Department of Agriculture, Natural Resources Conservation Service, Source Data Scale - 1:15,840
"New Jersey Important Farmlands Inventory", Originator - New Jersey Natural Resources Conservation Service, September 24, 1990.

Note:
This map was created by recoding data contained in the SSURGO database created by U.S. Department of Agriculture, Natural Resources Conservation Service. Information in the "New Jersey Important Farmlands Inventory", published by the New Jersey Natural Resources Conservation Service in September 24, 1990, is the source applied to the SSURGO database to determine soils which are prime, statewide important or locally important in nature.

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Figure 11

Soil Suitability Classes - N.J.A.C. 7:9A

The Sourland Mountain

A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

- I; IISc
- I; IISr
- I; IIWr:IIWrSc; IISc
- I; IIWr; IISc; IIWrSc
- IISc
- IISr
- IISc; I
- IISc; IISr
- IISc; IIISr
- IIIHr
- IIIHr, Wp(IISc); IISr, Wp (IISc)
- IIIHrWp
- IIIHrWp(IISc); IIWpSrSc; IIWrSc
- IIIHrWp; IIIHrWp(IISc); IIIHrWp(IISr)
- IIIHrWpWr
- IIISrWp
- IIISrWp(IIHc)
- IIISrWp; IIIHrWp
- IIISrWp; IIIHrWp(IISc)
- IIISrWp; IIISrWr
- IIISrWr
- IIIWp(IISr)
- IIIWr
- Udorthents
- Water
- Disturbed Ground
- Excessively Stony

Data Sources:
Soil Survey Database for Somerset County, Originator - U.S. Department of Agriculture, Natural Resources Conservation Service, Source Data Scale - 1:15,840
"Standards for Individual Subsurface Disposal Systems", State of New Jersey Administrative Code, N.J.A.C. 7:9A, New Jersey Department of Environmental Protection, Division of Water Quality, Bureau of Non-Point Pollution Control, August 15, 1999.

Note:
In order to display soil suitability classes as defined in N.J.A.C 7:9A, soil polygons as mapped by the USDA NRCS were recoded by soil series. Specific data on soil suitability classes was derived from Appendix D of "Standards for Individual Subsurface Disposal Systems", State of New Jersey Administrative Code, N.J.A.C. 7:9A, New Jersey Department of Environmental Protection, Division of Water Quality, Bureau of Non-Point Pollution Control, August 15, 1999.

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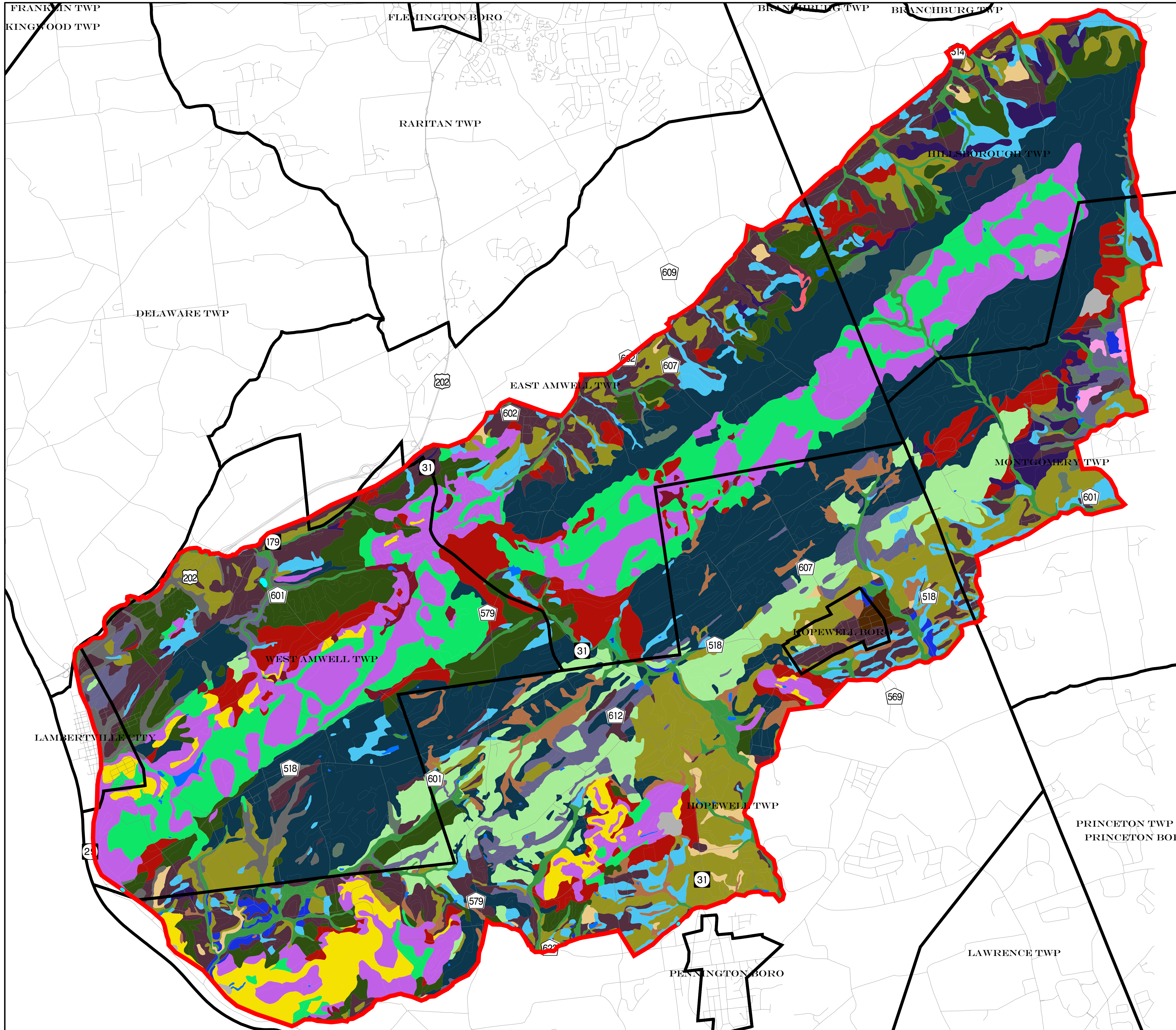

Figure 12

Soils Generally Unsuitable for Septic Systems - N.J.A.C. 7:9A

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

Soils Generally Unsuitable for Septic

Data Sources:
Soil Survey Database for Somerset County, Originator - U.S. Department of Agriculture, Natural Resources Conservation Service, Source Data Scale - 1:15,840
"Standards for Individual Subsurface Disposal Systems", State of New Jersey Administrative Code, N.J.A.C. 7:9A, New Jersey Department of Environmental Protection, Division of Water Quality, Bureau of Non-Point Pollution Control, August 15, 1999.

Note:
"Soils Generally Unsuitable for Septic Systems", as depicted on this map, were derived from Table 10.1 of "Standards for Individual Subsurface Disposal Systems", State of New Jersey Administrative Code, N.J.A.C. 7:9A, New Jersey Department of Environmental Protection, Division of Water Quality, Bureau of Non-Point Pollution Control, August 15, 1999. Table 10.1 lists soils which the Department classifies as unsuitable for septic system installation based on soil suitability class.

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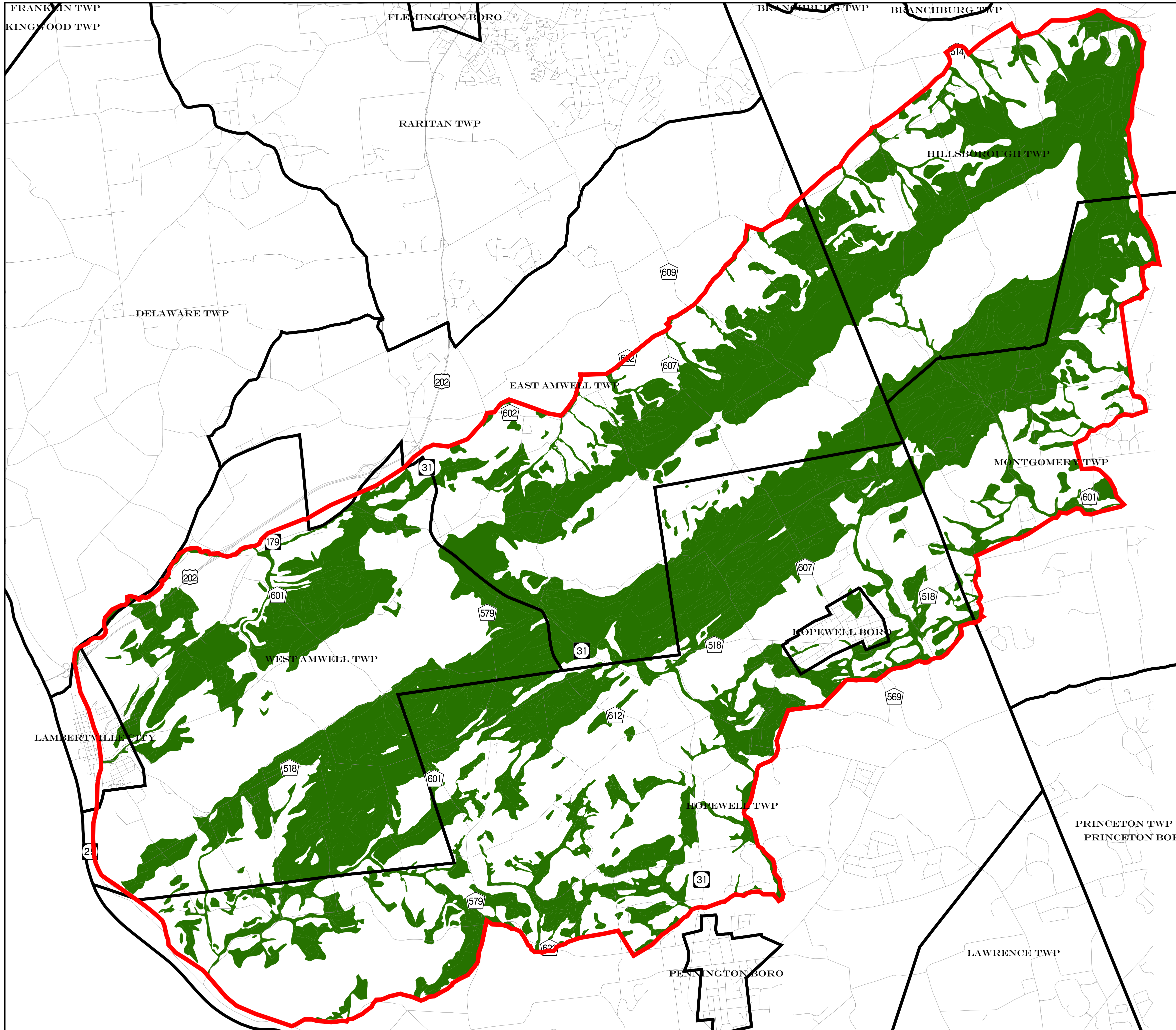

Figure 13

Depth to Bedrock

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

- 0 Inches
- 10 Inches
- 10 to 20 Inches
- 20 to 40 Inches
- 40 Inches
- 40 to 60 Inches
- 40 to 72 Inches
- 42 Inches
- 42 to 60 Inches
- 48 Inches
- 48 to 60 Inches
- 48 to 72 Inches
- 48 to 99 Inches
- 60 Inches
- 72 Inches
- 72 to 99 Inches

Data Sources:
Soil Survey Database for Somerset County, Originator - U.S. Department of Agriculture, Natural Resources Conservation Service, Source Data Scale - 1:15,840

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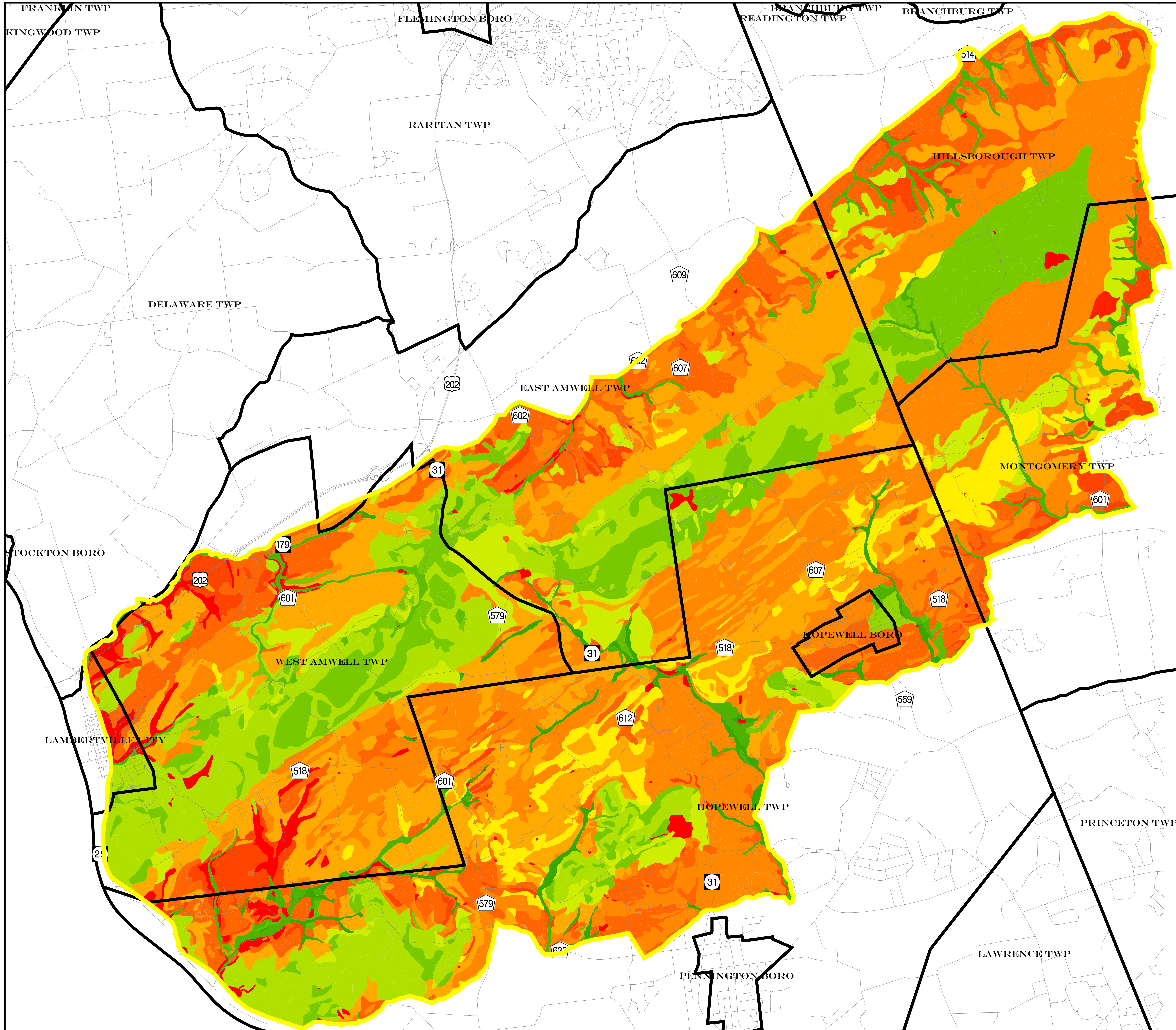

Figure 14
Depth to Seasonal High Water

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

- 0 Feet
- 0 to 0.5 Feet
- 0 to 1 Feet
- 0.5 to 1.5 Feet
- 0.5 to 2 Feet
- 0.5 to 2.5 Feet
- 0.5 to 3 Feet
- 1 to 2 Feet
- 1 to 2.5 Feet
- 1 to 3 Feet
- 1.5 to 3 Feet
- 2 Feet
- 4 Feet
- 6 Feet

Data Sources:
Soil Survey Database for Somerset County, Originator - U.S. Department of Agriculture, Natural Resources Conservation Service, Source Data Scale - 1:15,840

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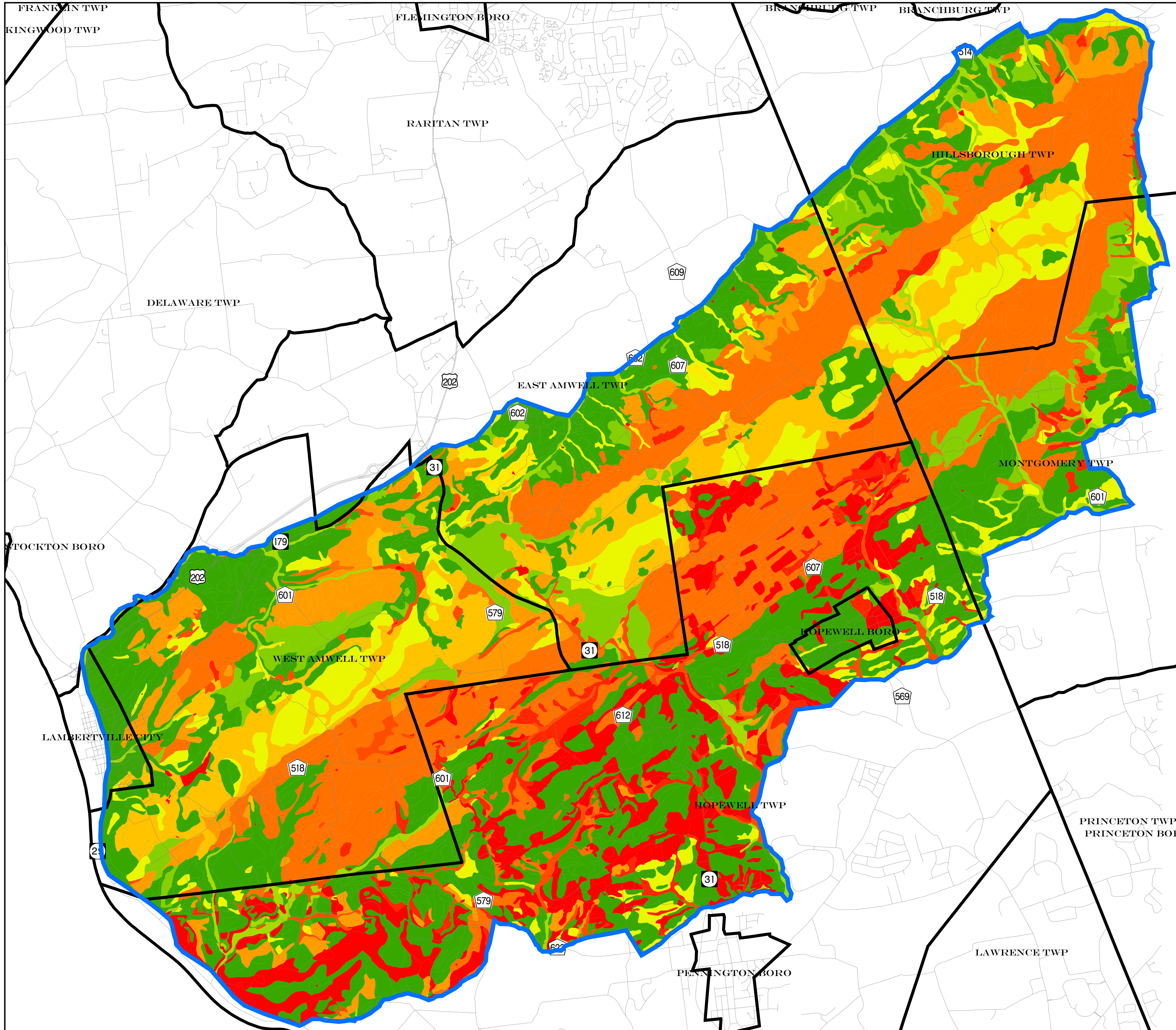

Figure 15

Highly Erodible Lands Class

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

Highly Erodible

Potentially Highly Erodible

Not Highly Erodible

Data Sources:
Soil Survey Database for Somerset County, Originator - U.S. Department of Agriculture, Natural Resources Conservation Service, Source Data Scale - 1:15,840

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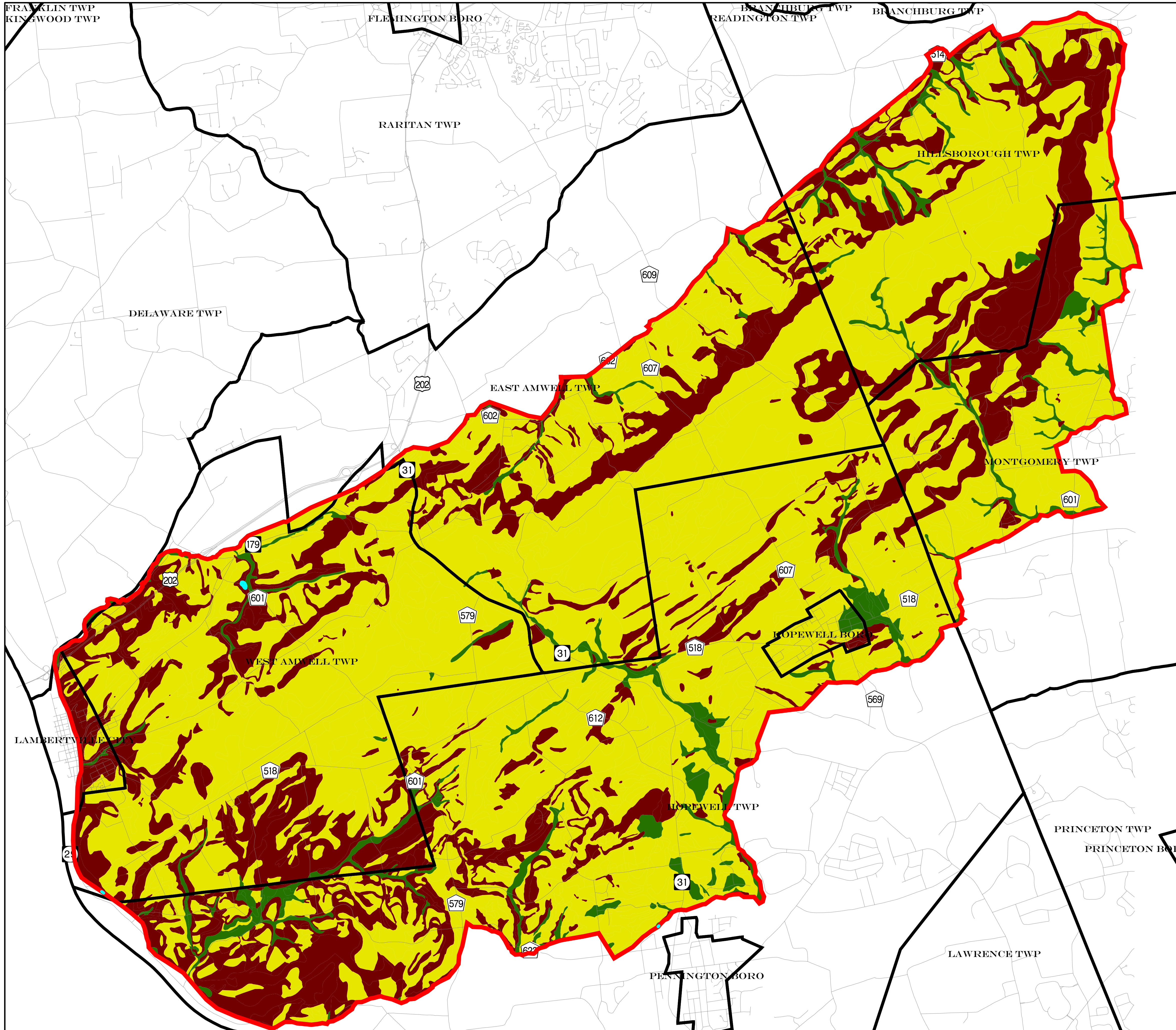

Figure 16
Surface Waters and Drainage Areas

The Sourland Mountain

A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

- Major Drainage Basin Divide
- Alexauken Creek
- Back Brook
- Back Brook (Somerset)
- Baldwins Creek
- Beden Brook
- Cruser Brook
- D&R Canal
- Fiddler's Creek
- Jacob's Creek
- Moore Creek
- Neshanic River
- Pike Run
- Pleasant Run
- Rock Brook
- Royce Brook
- Stony Brook
- Swan Creek

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
"NJDEP 14 Digit Hydrologic Unit Code delineations for New Jersey", Originator - NJDEP and NJGS, Source Data Scale - 1:24,000.

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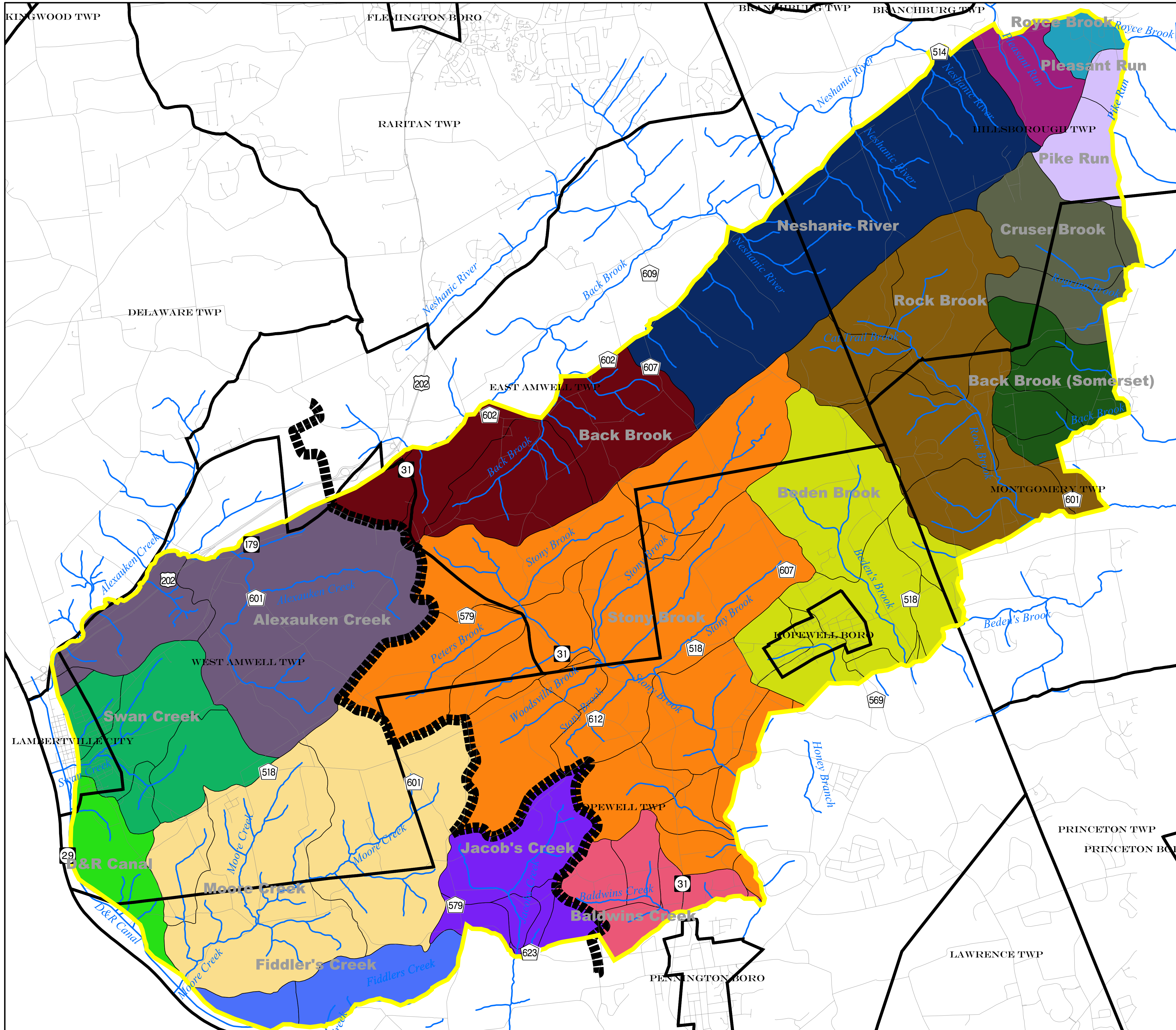

Figure 17

HUC 14 Subwatershed Boundaries

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

- Major Drainage Basin Divide
- 02030105030050
- 02030105030060
- 02030105040010
- 02030105090010
- 02030105090020
- 02030105090030
- 02030105090040
- 02030105090050
- 02030105110040
- 02030105110050
- 02030105110060
- 02030105110070
- 02030105110080
- 02030105110090
- 02030105110100
- 02030105110150
- 02040105210010
- 02040105210020
- 02040105210030
- 02040105210040
- 02040105210050
- 02040105210060

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Source:
"NJDEP 14 Digit Hydrologic Unit Code delineations for New Jersey", Originator - NJDEP and NJGS, Source Data Scale - 1:24,000.

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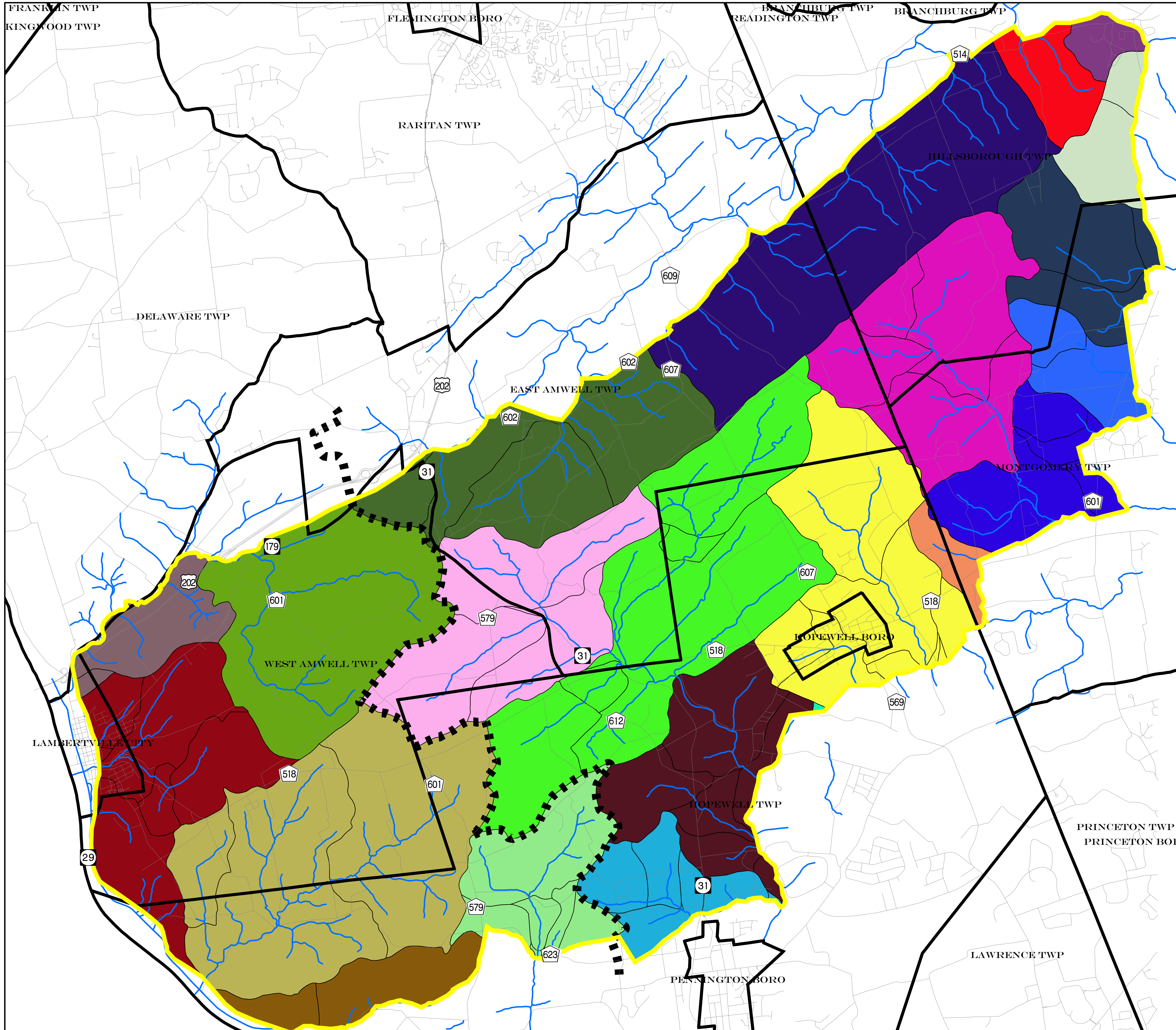

Figure 18
AMNET Biological Monitoring Sites
The Sourland Mountain Region
A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

AMNET Monitoring Site

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Source:
"NJDEP Ambient Biomonitoring Network (AMNET) 2000", Originator - New Jersey Department of Environmental Protection (NJDEP), Bureau of Freshwater Biological Monitoring (BFBM), Source Data Scale - 1:24,000

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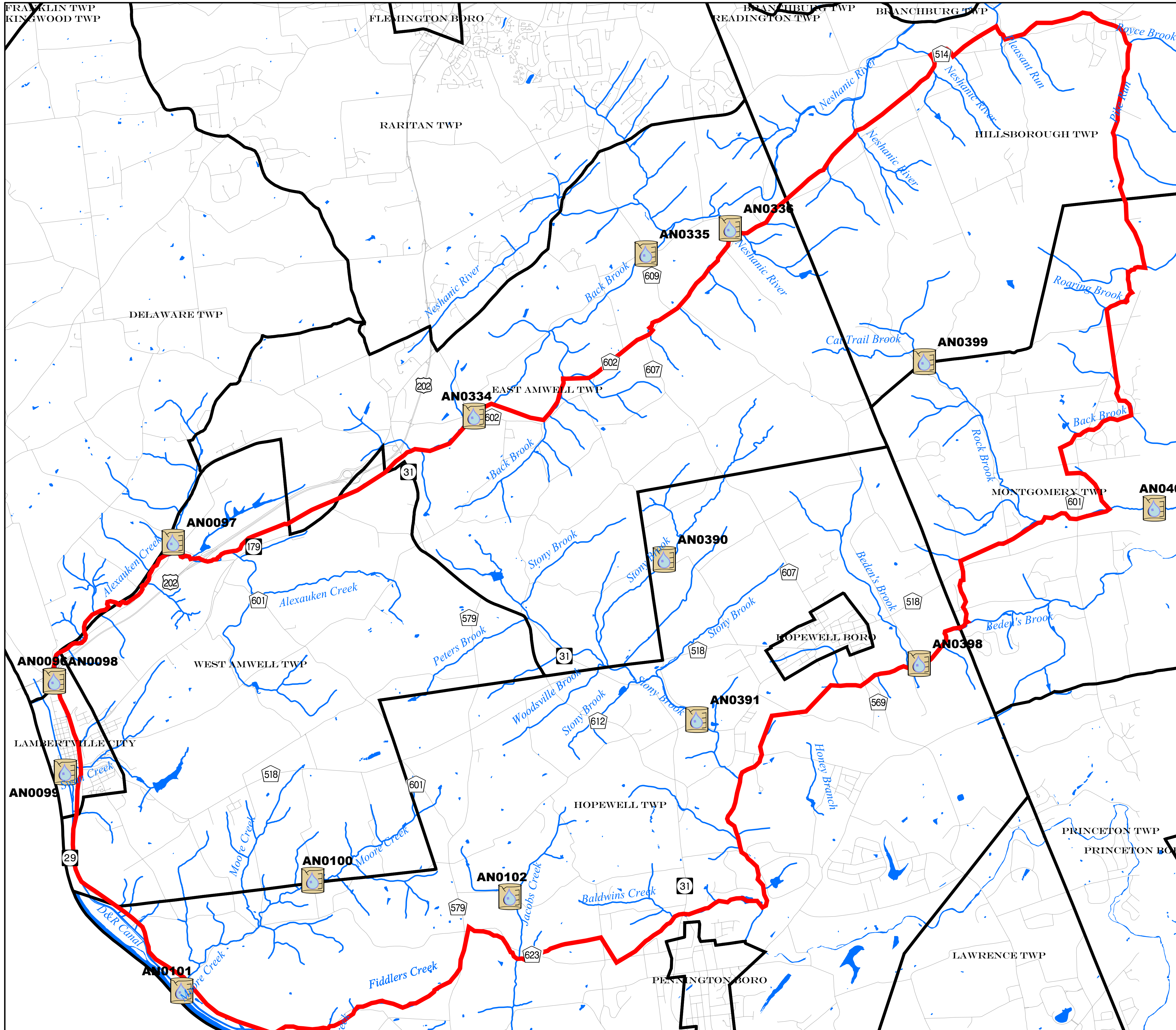
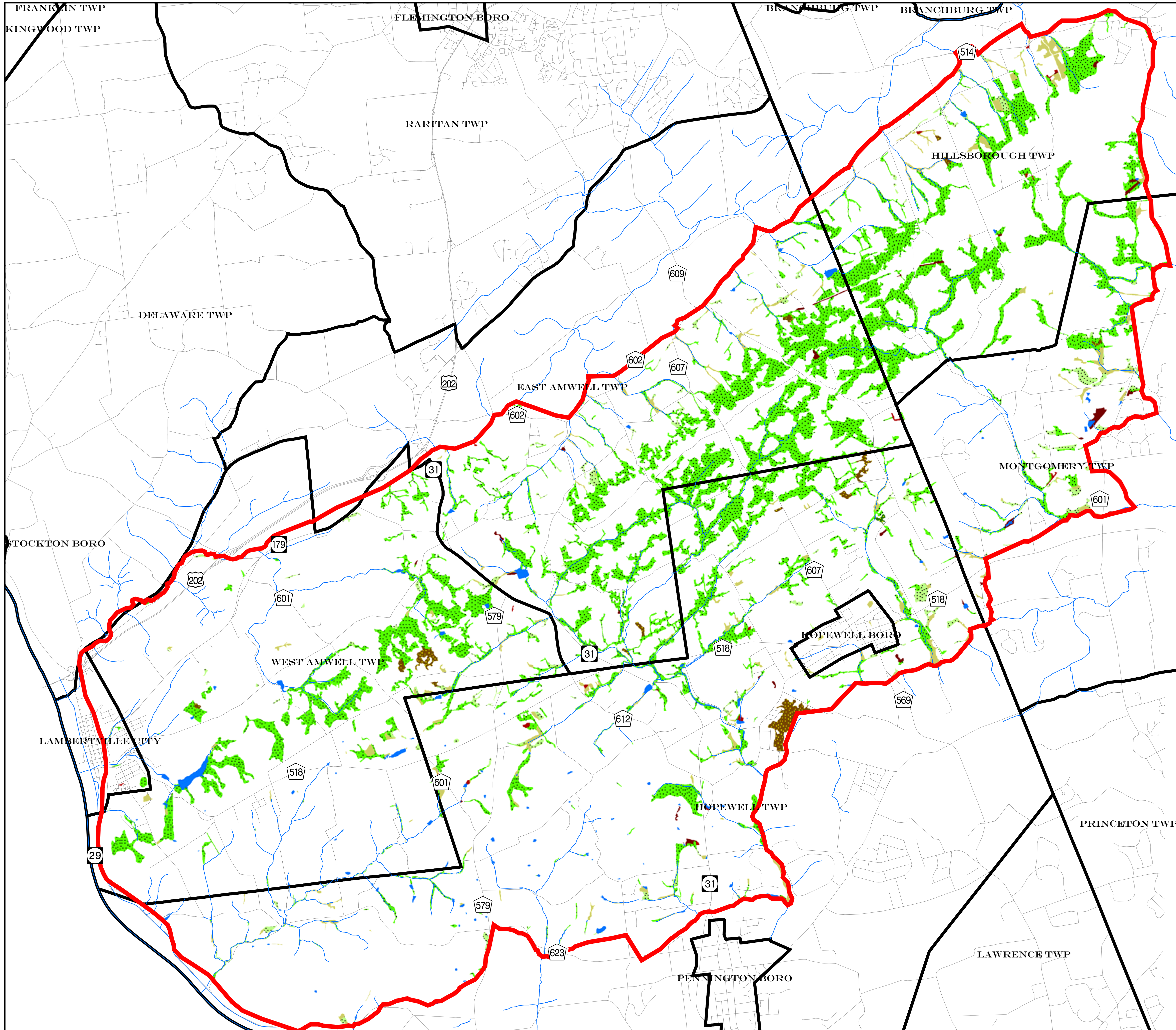


Figure 19
Wetlands

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 Miles



Legend

- Agricultural Wetlands
- Coniferous Wooded Wetlands
- Deciduous Wooded Wetlands
- Mixed Wooded Wetlands
- Disturbed Wetlands
- Managed Wetland
- Water
- Wetlands

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
1995 Land Use/Land Cover Edition 1.3 - WMA 10 (Millstone Watershed Management Area), Originator - NJDEP, OIRM, BGIA, Source Scale 1:12,000.

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Figure 20

FEMA Floodzones

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2
Miles

Legend

- 100-Year Floodplain - No BFE's Determined
- 100-Year Floodplain - BFE's Determined
- 100-Year Floodplain - Average Depths Determined
- 500-Year Floodplain

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
"Q3 Digital Flood Data", Originator - FEMA, Source Data Scale 1:24,000.

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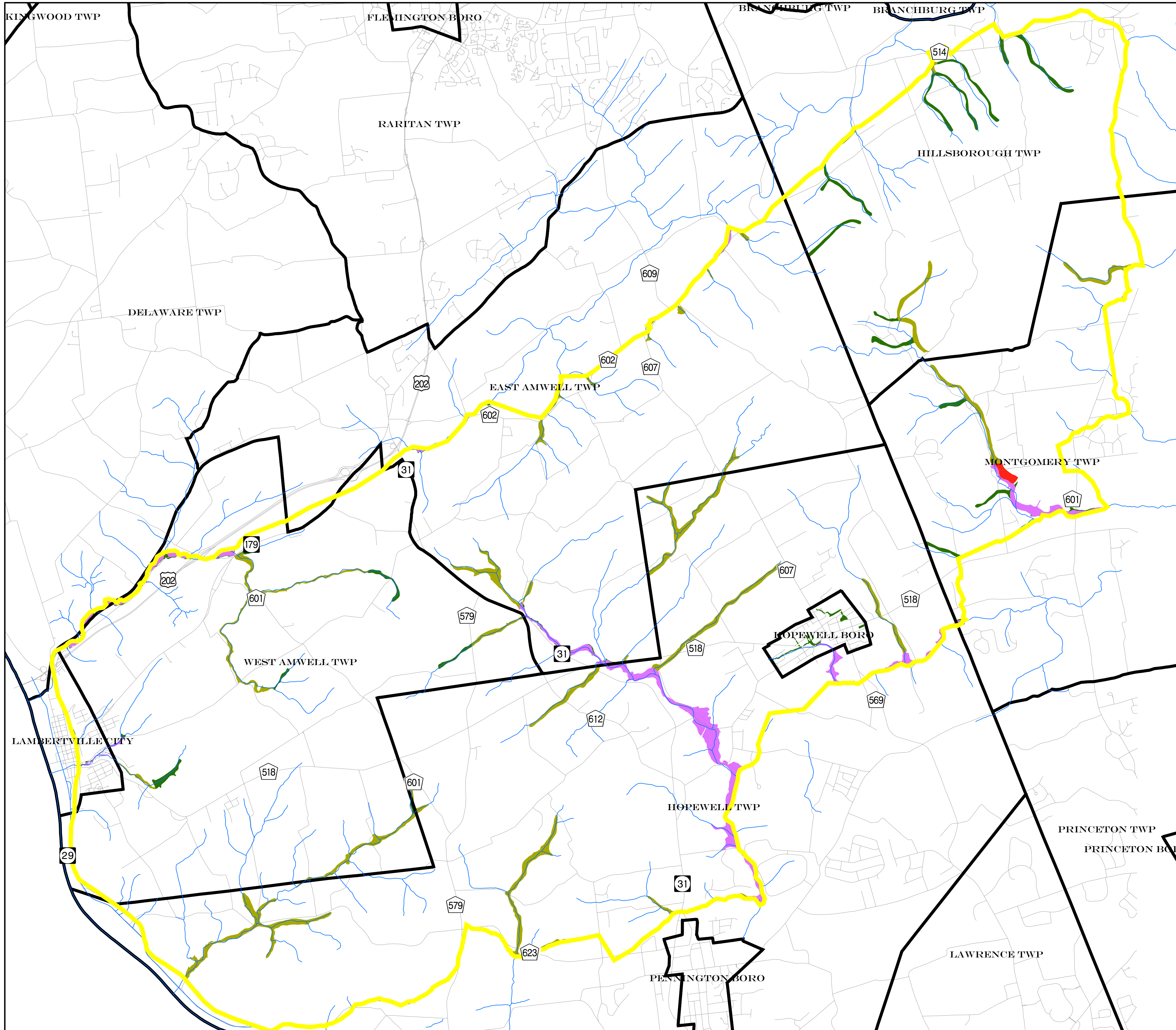

Figure 21

Riparian Areas and 1995 Forested Areas

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

1995 Forested Areas

Riparian Areas

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
1995 Land Use/Land Cover Edition 1.3 - WMA 10 (Millstone Watershed Management Area), Originator - NJDEP, OIRM, BGIA, Source Scale 1:12,000.
"NJDEP Ambient Biomonitoring Network (AMNET) 2000", Originator - New Jersey Department of Environmental Protection (NJDEP), Bureau of Freshwater Biological Monitoring (BFBM), Source Data Scale - 1:24,000
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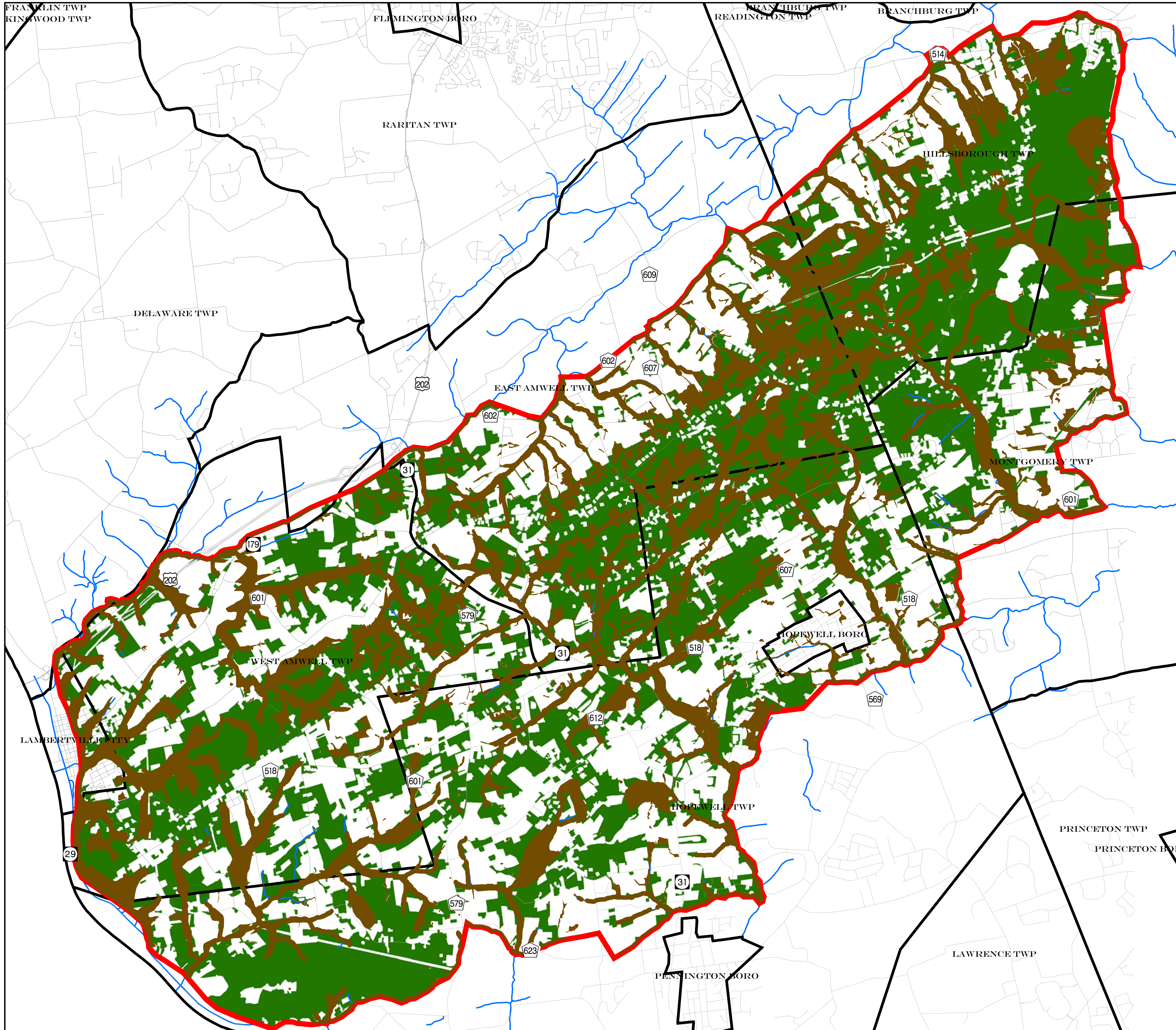


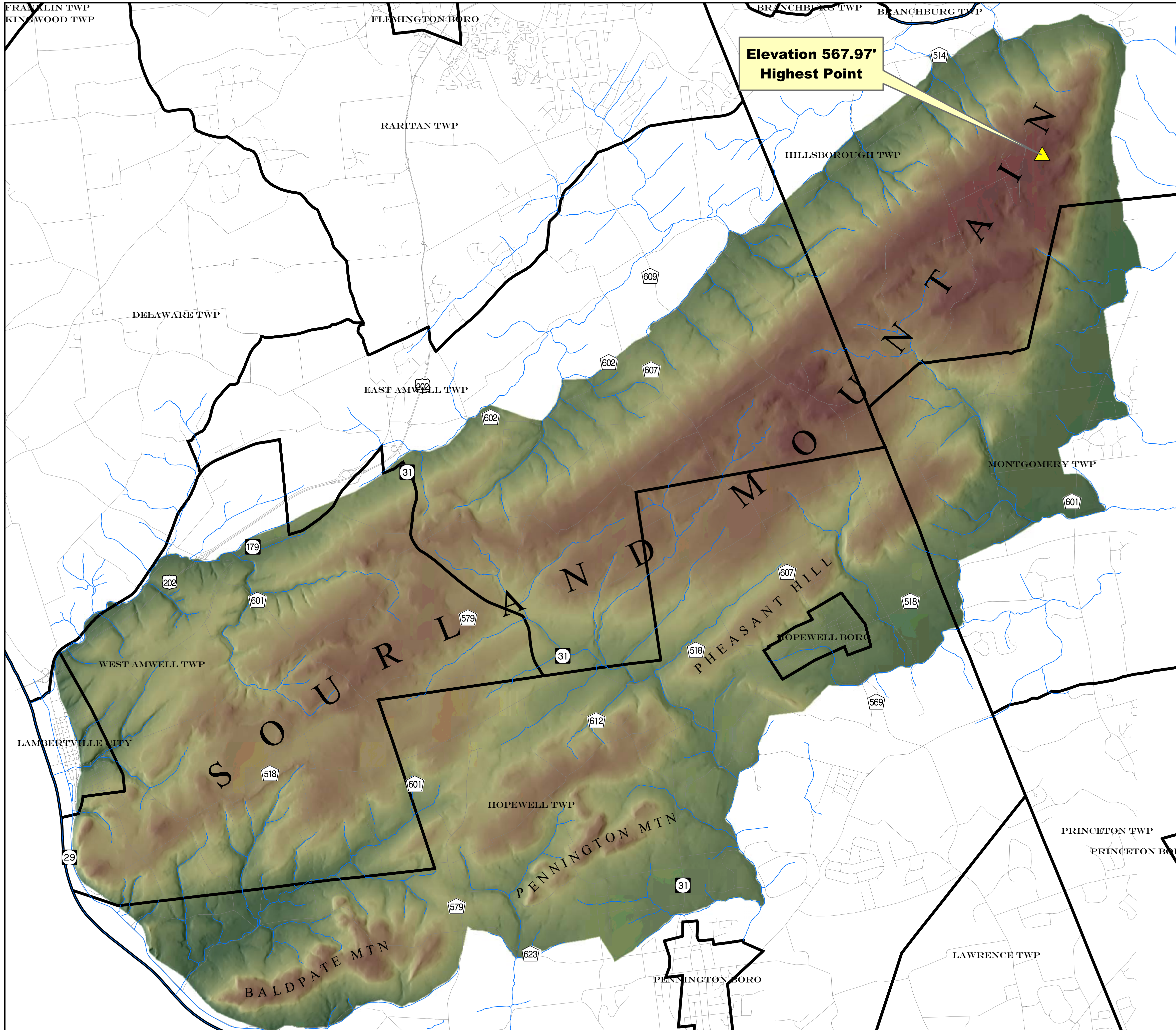
Figure 22

Topographic Features

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 Miles



This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
GIS DEM (10 Foot Grid), NAVD 88,
derived fromTIN interpolated from 2 foot DTM based on
1996 1"=100' groundscale orthophotography by ProMaps, Inc.

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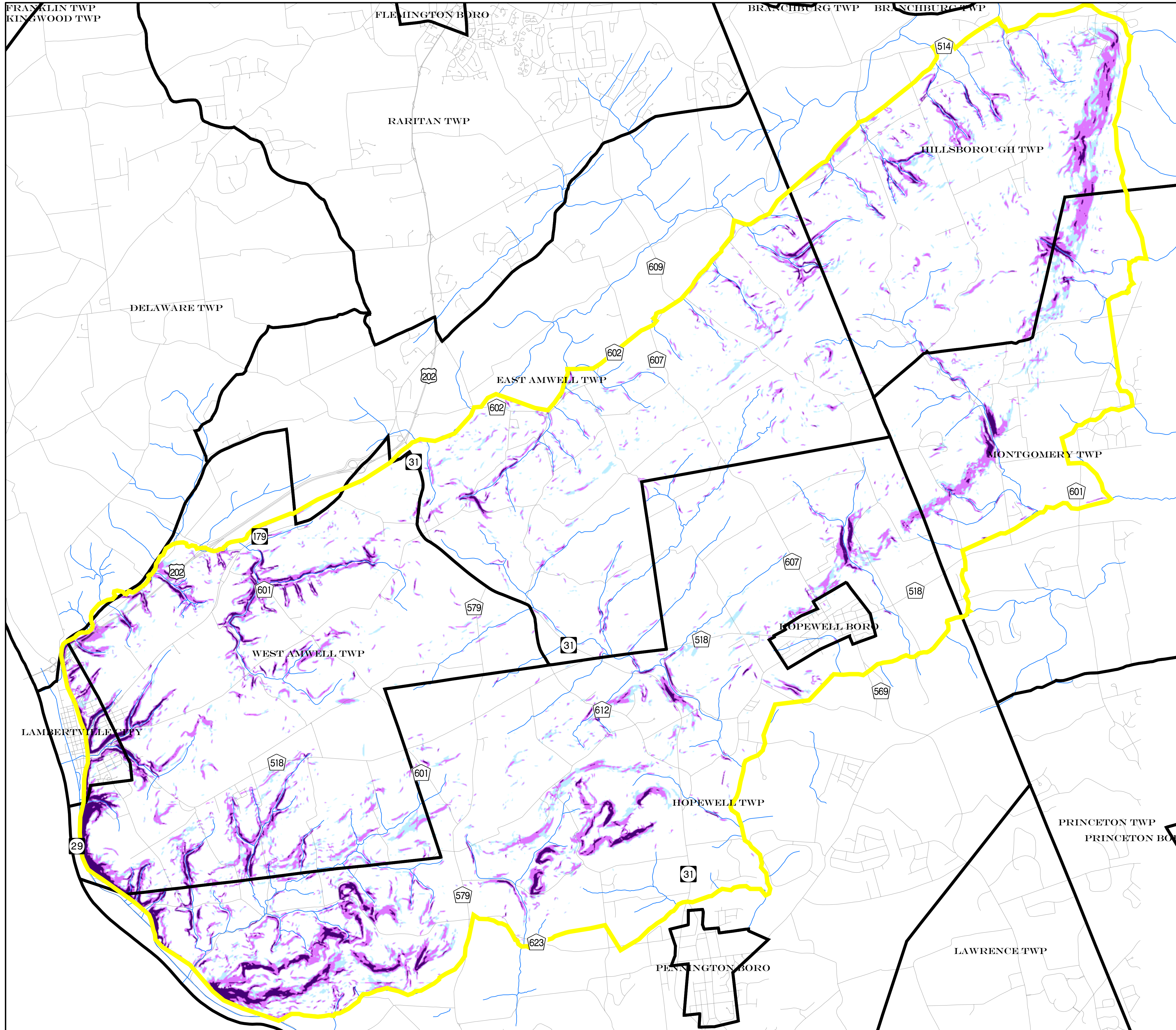
Figure 23
Steep Slopes

The Sourland Mountain Region

A Portion of Central New Jersey

0 0.5 1 2 Miles



Legend

- Slopes less than 12%
- Slopes 12% to 15%
- Slopes greater than 15% to 25%
- Slopes greater than 25%

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Source:
GIS DEM (10 Foot Grid), NAVD 88,
derived fromTIN interpolated from 2 foot DTM based on
1996 1"=100' groundscale orthophotography by ProMaps, Inc.

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Figure 24
Ridgelines and Contours
The Sourland Mountain
A Portion of Central New Jersey

0 0.5 1 2 Miles

Legend

- Ridgelines
- 20 Foot Contour
- 100 Foot Contour

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
GIS DEM (10 Foot Grid), NAVD 88,
derived fromTIN interpolated from 2 foot DTM based on
1996 1"=100' groundscale orthophotography by ProMaps, Inc.

Note:
Ridgelines were established manually using 3-dimensional DEM and contour information.

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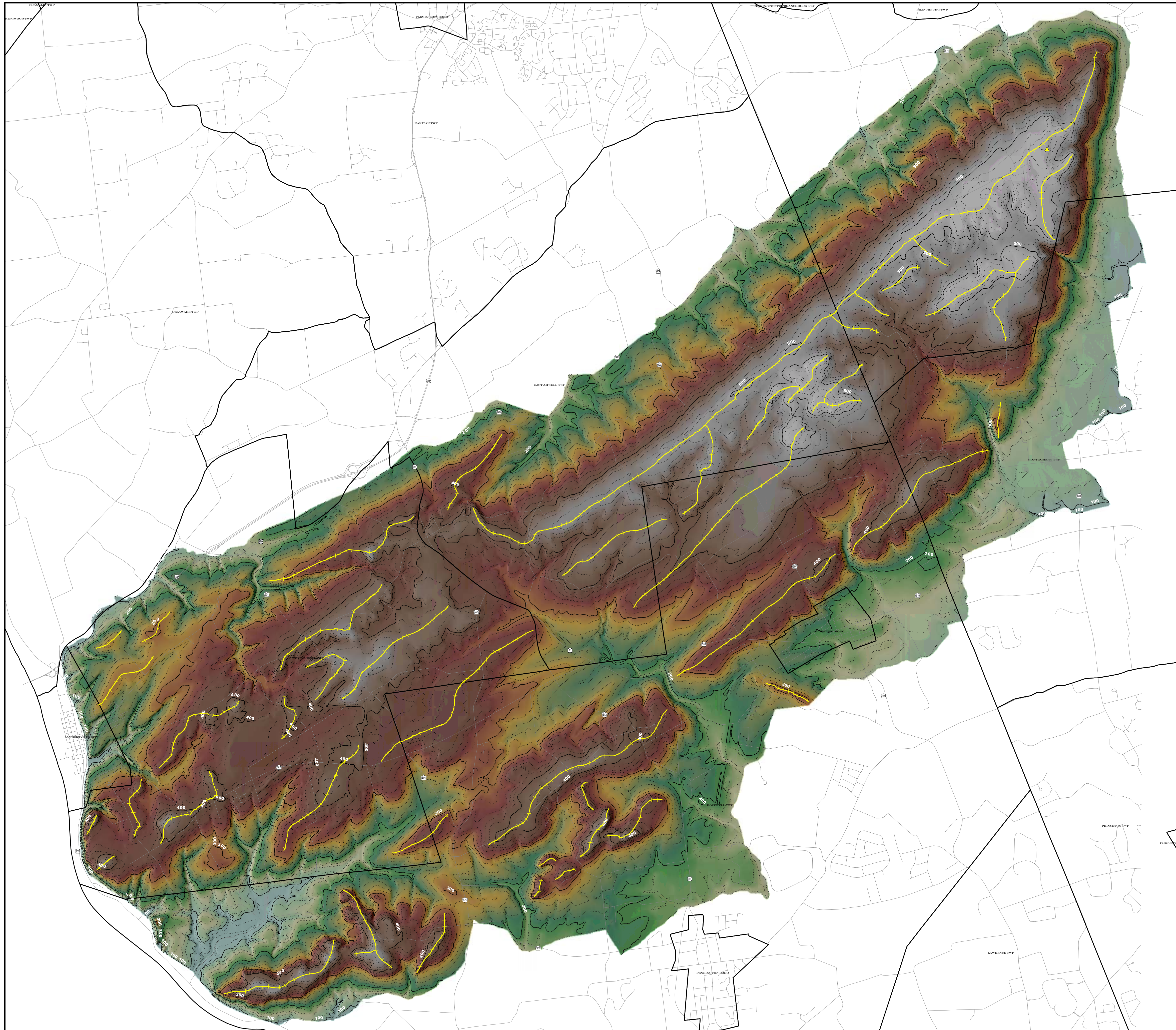

Figure 25

New Jersey Landscape Project Habitat Data

The Sourland Mountain Region

A Portion of Central New Jersey

Rank	Indication
1	Suitable habitat with no field survey conducted
2	Habitat patch with State special concern species present
3	Habitat patch with State threatened species present
4	Habitat patch with State endangered species present
5	Habitat patch with Federal threatened or endangered species present

0 0.5 1 2 Miles

Legend

Wood Turtle Foraging

Forest
- Rank 1
- Rank 2
- Rank 3
- Rank 4

Emergent
- Rank 1
- Rank 2

Grassland
- Rank 1
- Rank 2
- Rank 3
- Rank 4

Forested Wetland
- Rank 1
- Rank 2
- Rank 3

This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been NJDEP verified and is not State-authorized.

Data Sources:
NJDEP Landscape Project Critical Habitat Data, Originator - NJDEP, Division of Fish and Wildlife, Endangered NonGame Species Program, Source Data Scale - 30 Meter Resolution. 2/04

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